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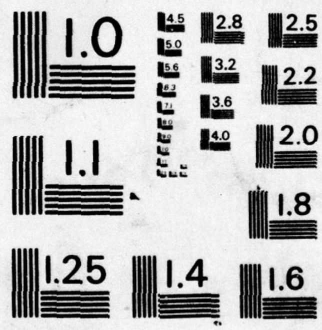

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ATMOSPHERE EXPLORER MESA ACCELEROMETER DATA PROCESSING SYSTEM

Edited by Robert W. Fioretti
RDP, Incorporated
391 Totten Pond Road
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409955

FINAL REPORT

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AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
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This report summarizes the data processing required to systematically extract scientifically meaningful data from the accelerometer experiment flown aboard the Atmosphere Explorer series of satellites. Many of the results given will be incorporated by analysts and experimenters into presentations given at scientific meetings.

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FOREWORD

The efforts described herein were performed under contract to the Atmosphere Structures Branch (LKB), Aeronomy Laboratory of the Air Force Geophysics Laboratory (AFGL), Hanscom Air Force Base, Massachusetts.

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1. INTRODUCTION

The efforts described herein are part of a project to develop and implement a data processing software system for the management and analysis of data received from the AFGL MESA (Miniature Electrostatic Accelerometer) experiment flown aboard the NASA Atmosphere Explorer (AE) series of satellites. To accomplish this task a Xerox Sigma-9 computer system – dedicated to the AE project – is being utilized in a time-shared environment. Telemetry data from the major experiments aboard AE are transmitted from remote stations to NASA's Goddard Space Flight Center (GSFC), and these data are then stored on mass storage devices for use by experimenter's software. Reduced and analyzed experiment data are later stored on mass storage devices for use by all other experimenters and theoretical analysts.

The MESA Data Reduction System (DRS) which has been developed is capable of extracting raw telemetry data from the AE data base, editing and temperature-correcting the telemetry data, extracting atmospheric drag values utilizing digital filtering techniques, and calculating atmospheric density and wind data. In addition, the MESA DRS calculates Jacchia 71 model density values, lists and displays calculated parameters on printer plots and/or microfilm, and stores output data in files for on-line use by other experimenters. This system is presently being utilized in a production environment to produce reduced MESA density data from three AE satellites on a timely basis.

This report will describe the AE satellite, the AE data system, the MESA experiment, and the MESA data processing system.

1.1 The AE Satellites

The Atmosphere Explorer satellites are a series of maneuverable, unmanned spacecrafts whose purpose is to investigate the physical properties, dynamics and photochemical processes in the upper atmosphere. The spacecrafts differ from the usual unmanned scientific satellites in that each contains an on-board propulsion system which permits variation of perigee and apogee altitudes; in the team approach taken by investigators to analyze and compare data; in the normal AE spacecraft and data-collecting operations; and in the concommitant rapidity with which data must be forwarded, processed and analyzed.

Linked through a dedicated ground-based computer operated in a timeshared environment with scientists in various parts of the country, the AE satellites carry as many as fourteen scientific experiments designed to provide data on natural processes and phenomena in the earth's thermosphere.

The AE-C spacecraft was launched from Vandenburg Air Force Base, California on 16 December 1973 at 06:18 GMT into an elliptical orbit with apogee at about 4000 km, perigee at 156 km, and an inclination of 68.4 degrees. AE-D was launched from Vandenberg Air Force Base on 6 October 1975 at 09:00:49 GMT into a polar orbit. Initial apogee was about 3800 km, perigee 156.4 km and the inclination was 90.1 degrees. The third satellite in the series, AE-E, was launched from Cape Canaveral, Florida on 20 November 1975 at 02:06:48 GMT. It was injected into an elliptical equitorial orbit with apogee at 3025 km, perigee 156.9 km, and an inclination of 19.7 degrees.

The AE mission objective, to study phenomena in the atmosphere at altitudes above 120 km, was to be accomplished by each satellite in two orbital phases: elliptical orbit and circular orbit. During the

first few months in orbit, the perigee of each satellite was to be periodically lowered to within the altitude ranges of 130 km to 160 km. This was to provide data on the thermosphere – a region that has been essentially unexplored on a continuous basis. After these excursions the spacecrafts were to be moved slowly into circular orbits at specified altitudes.

AE-C successfully completed its elliptical phase and was circularized in December 1975, at about 240 km. AE-D and AE-E are presently in the elliptical phase of their respective missions.

This combination of both elliptical and circular orbits taken on polar and equitorial orbiting satellites will provide global coverage of the upper atmosphere. Hopefully, this will aid in separating such atmospheric effects due to altitude, latitude, and solar radiation.

Reduced geophysical data are stored in the central computer and are shared among all AE scientists. This permits unified attacks on the relevant problems and also allows a minimal delay in the publication of results.

A more detailed description of the AE satellite may be found in Reference [1].

1.2 The AE Data System

The AE Central Computer located at Goddard Space Flight Center (GSFC), Greenbelt, Maryland, consists of a Xerox Sigma-9 computer system under the Control Program No. 5 (CP-5) Operating System. The Sigma-9 is equipped with 1.28 megabytes (320K 32-bit words) of core storage, 10.6 megabytes of Rapid Access Device (RAD) on-line storage, 800 megabytes of high speed disk on-line storage, and 10 9-track drives (seven 1600-bpi drives and three 800-bpi drives). A Xerox Sigma-3 computer, which is connected to the Sigma-9 computer, is used as a controller to interface with various Sanders 810 programmable terminal systems located at GSFC and the experimenters remote sites. Hardwire data links to the Sigma-9 provide spacecraft telemetry data input from the Input Processor Computer (Xerox Sigma-5) and orbit/attitude data input from the Orbit/Attitude Processor Computer (IBM S/360-95).

The AE Central Computer is dedicated to the support of the AE-C, AE-D, and AE-E missions. In particular, most of the processing on the Central Computer involves the reduction and analysis of data from on-board experimental equipment. The development of software systems to perform these functions is the responsibility of individual investigators. To simplify this development and to ensure flexibility in data handling and sharing between investigators, standardized data bases have been established for the Central Computer which are accessible through the Fortran language by using custom designed interface routines. The data bases utilized by investigators are:

a) Time-smoothed telemetry data
b) Orbit/attitude data
c) Magnetic solar activity data
d) Geophysical unit data (separate file structures for each experiment after initial data reduction)

e) Unified abstract data (summary results from each experiment combined in a single file structure).

These data bases are maintained on disk and tape storage. In general, disk storage is used for the most recent data available, and tape storage is used for permanent storage as well as backup for the data on disk. Figure 1 illustrates the location of disk storage to those data bases requiring large amounts of space.

A variety of software resources are available on the Central Computer which simplify monitoring as well as processing these data bases. The majority of these resources are included in the Data Management Facility (DMF) developed under the auspices of the GSFC Information Processing Division. These responsibilities include:

a) Original creation and maintenance (updating) of the data bases.
b) Management of data base storage space (disk and tape).
c) Software interfaces (FORTRAN callable) for reading and (when applicable) writing the data bases.
d) On-line query capabilities for data base status and summary data information.
e) Utility programs for data base manipulation.

A more detailed description of the Data Management Facility and its use may be found in Reference [2].

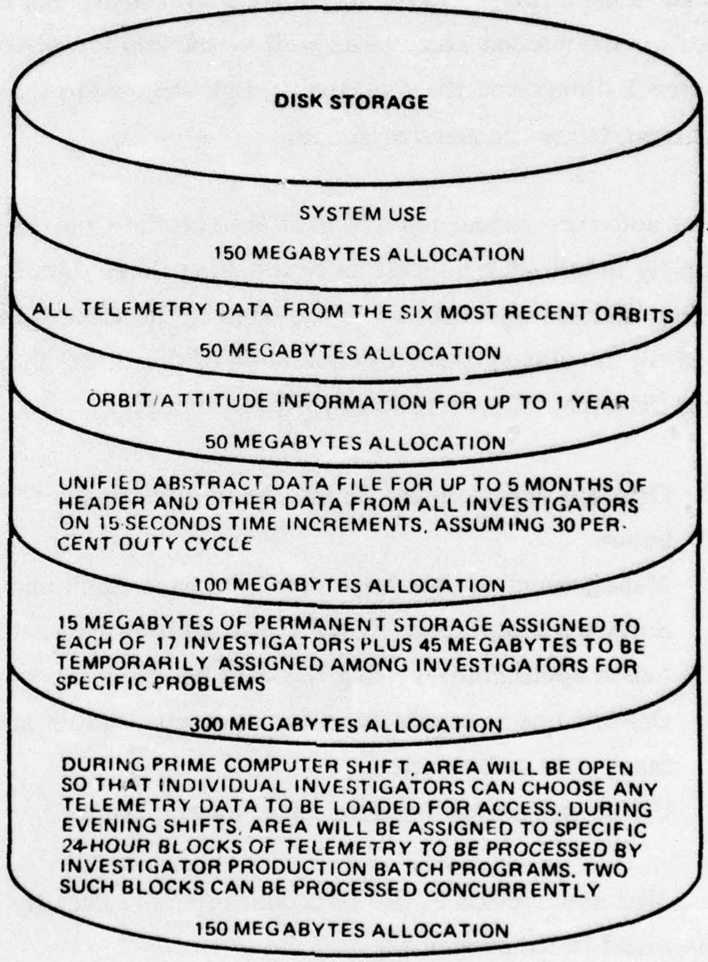


Figure 1. AE Central Computer Disk Storage Allocation

1.3 The MESA Experiment

The MESA experiments on the AE satellites were designed to provide accurate neutral atmospheric density measurements by measuring satellite deceleration caused by aerodynamic drag. The individual MESA unit is a uniaxial accelerometer. It consists of an electrostatitically suspended proof mass which is also electrostatically rebalanced along a sensitive axis. The MESA determines an applied acceleration from the electrostatic force required to recenter the proof mass.

The output of the MESA is a digital pulse rate proportional to the sensed input acceleration. Vehicle dynamics, the momentum wheel, propulsion system thrusting, and instrument motions provide input "noise" accelerations. These noise accelerations are to be removed in the data analysis in order to retrieve the desired "signal" accelerations due to atmospheric drag.

Three single-axis miniature electrostatic accelerometers were flown on each of the AE missions. Two sensors were placed with their sensitive axes in the spacecraft xy plane. Sensor yx was placed at the center of gravity with the sensitive axis 45° from the +x-axis in the +x, -y quadrant, and sensor xy is placed adjacent to yx with the sensitive axis 45° from the +x-axis in the +x, +y quadrant and with the center of the proof mass on the spin axis. These two instruments are used to provide redundant capability for density measurement, particularly during the despun mode, as well as monitoring the orbit-adjust propulsion system. The third sensor was placed with its sensitive axis along the spacecraft z-axis. This sensor can be used to monitor spacecraft roll, particularly in the despun mode of operation.

The MESA sensors have the capability of being commanded into any of three sensitivity ranges:

Range	Full scale (g's)
A	8×10^{-3}
B	4×10^{-4}
C	2×10^{-5}

Range A was commanded for satellite thrust monitoring and was not used for density measurement. Emphasis in this report will be given to data taken from sensors in range B, since most density data were taken in this range. The altitude region in which drag can be measured for each sensitivity range is as follows:

Range A	120 to 160 km
Range B	122 to 280 km
Range C	180 to 320 km

Each sensor determines the component of drag along a single axis only.

Once the component of the drag acceleration is calculated for each single axis, the total drag acceleration may be calculated in one of three ways. First, if three instrument axes are active, the total drag acceleration A_D is

$$A_D = \left(\sum_{i=xy,\,yx,\,z} \left(\frac{a_i}{s_i}\right)^2 \right)^{1/2} ,$$

where a_i = drag acceleration component of the i^{th} accelerometer
s_i = i^{th} accelerometer scale factor.

Secondly, if any one accelerometer is turned on, the total drag acceleration may also be derived from that single axis separately by

$$A_D = \frac{a_i}{s_i \cos \alpha_i} ,$$

where $\cos \alpha_i$ is the angle between the i^{th} accelerometer sensitive axis and the satellite's velocity vector.

It is important to note that since the accelerometer outputs are averaged accelerations sensed over the sample interval (one-quarter second), the $\cos \alpha_i$ here should be an averaged value taken over the sample interval.

In the third case, if the xy and yx accelerometers are active, the total drag acceleration may be calculated by locating those times when the z-accelerometer's sensitive axis is making a 90° attack angle with the satellite's velocity vector. In that case, the drag along that axis should be zero and the total drag acceleration can be calculated by

$$A_D = \left(\sum_{i=xy,\,yx} \left(\frac{a_i}{s_i} \right)^2 \right)^{1/2} .$$

In any case, density is then derived from the following:

$$\rho = \frac{2m A_D}{C_D a V^2} ,$$

where ρ = atmospheric density
m/a = satellite mass to area ratio
A_D = total drag acceleration
C_D = satellite drag coefficient
V = satellite velocity.

A complete description of the MESA experiment may be found in Reference [3].

1.3.1 Digital filtering analysis

The approach taken to extract the message signal accelerations from the total signal accelerations is provided by statistical communication theory.

1.3.1.1 Despun orbits – In the case when the satellite is despun, atmospheric drag information assuming no wave motions, are sensed as zero frequency (DC) accelerations whose amplitudes vary between 10^{-8} and 5×10^{-4} g's depending upon satellite altitude. Satellite nutation modifies the MESA output signal with a sinusoidal modulation whose frequency is 0.14 – 0.2 Hz and whose amplitude is about 1.8×10^{-4} g's per degree of nutation of the XY sensor. Typically, nutation accelerations vary between 10^{-6} and 10^{-5} g's.

Sensor outputs are further modified by noise due to the rotation of the satellite's momentum wheel assembly (MWA). The momentum wheel rotation causes noise accelerations at high frequencies which are sensed by MESA. However, due to the telemetry data sampling rate, the modulations for the most part appear at 1.5–2.0 Hz. This effect is known as aliasing and is discussed in Reference [2]. The amplitude of the MWA noise accelerations is about 8×10^{-6} g's.

Instrument bias causes a DC-output component whose amplitude is about 1.4×10^{-6} g's. In the despun case, centripetal accelerations sensed by MESA are negligible.

Figure 2 displays a small segment of raw MESA data from the XY sensor taken on orbit 2217 at an altitude of about 170 km. Modulations on the output signal due to drag, nutation, MWA noise and instrument bias are shown.

Results of a power spectrum analysis of the XY sensor data are displayed in Figure 3 showing increased power due to (a) atmospheric

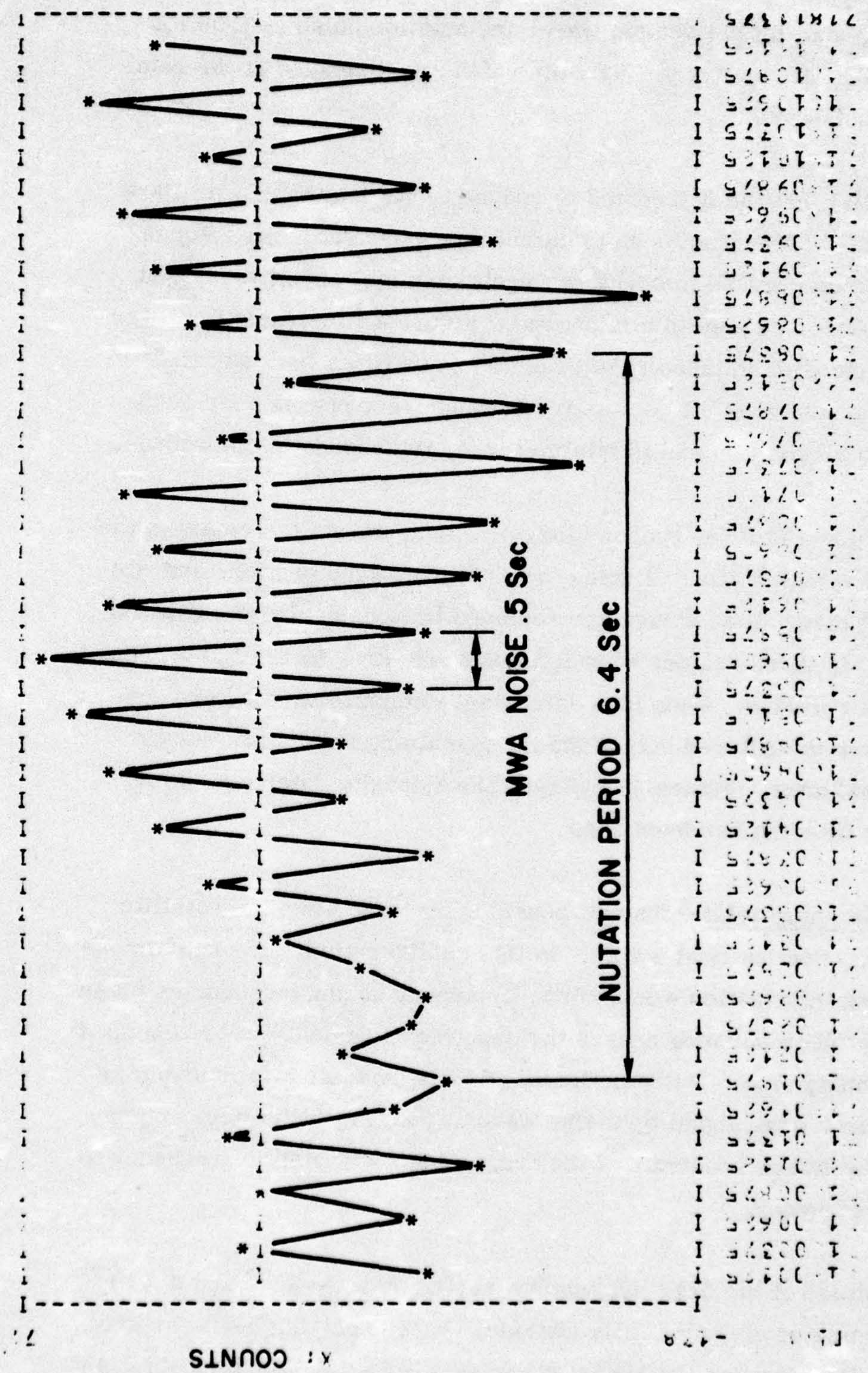


Figure 2. Raw MESA Data from XY—Sensor
Orbit 2217 Day 74180
Despun 170 KM Downleg

drag at DC, and (b) momentum wheel and nutation noise at 1.95 Hz and 0.156 Hz, respectively. Base line data are displayed at the relative white noise level.

It is essential that the filter used to reduce these data have near 100% response at low frequencies and minimum response at those frequencies where nutation and momentum wheel noise appear; that is, that filter side-lobes be kept to a minimum. Figure 4 illustrates the filter chosen to accomplish these requirements. The filter is designated "15 - 10" because it is a low pass filter whose response is near 100% from DC to 15 seconds and is minimal from 10 seconds to .5 seconds.

Since the "15 - 10" filter chosen allows DC components to remain in the data, what remains after filtering are: (a) drag accelerations and (b) instrument bias. Bias values are removed by considering the filtered output only in those regions where atmospheric drag is negligible, that is, at high altitudes. Once bias values are determined, they are subtracted from the filtered output and the remaining values are due to atmospheric drag. Figure 5 displays MESA density data from orbit 2217 after filtering has been done.

1.3.1.2 Spinning orbit – We now consider the case when the satellite is spinning, nominally at 4 rpm. In this configuration, although atmospheric drag information would normally appear at low frequencies (near DC) the satellite spinning causes the drag measurements to be "chopped" at the spinning rate. Mathematically, this is equivalent to multiplying the measured drag signal by a sine wave at the spin frequency. Equivalently, the power spectrum of the drag signal is shifted in frequency to the spin frequency.

The amplitude of the drag information varies between 10^{-8} and 5×10^{-4} g's depending upon the satellite altitude. In the spinning mode the spin axis nutation modifies the MESA output as a 0.1 - 0.11 Hz sinusoid. As

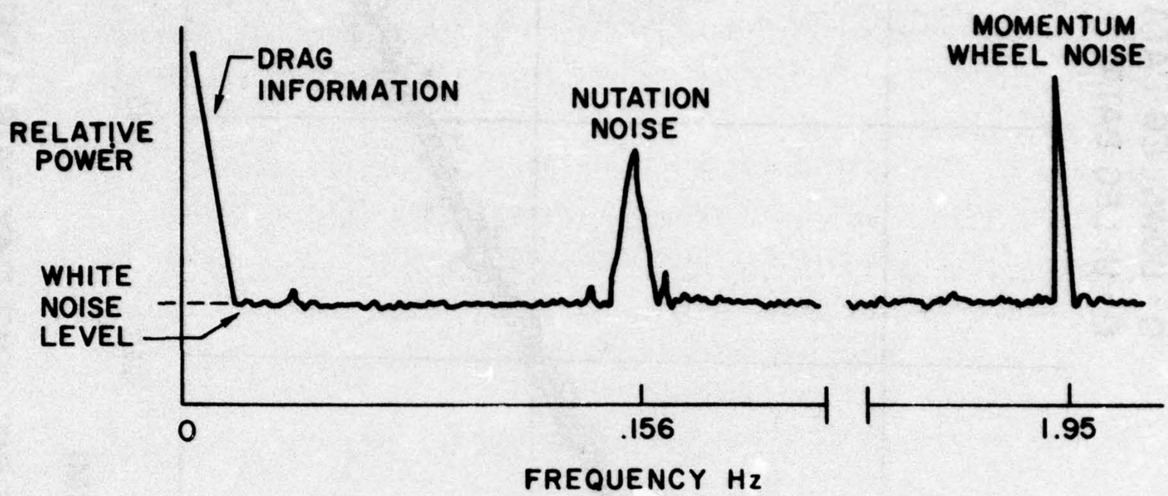


Figure 3. Power Spectrum Analysis
Orbit 2217 Day 74180

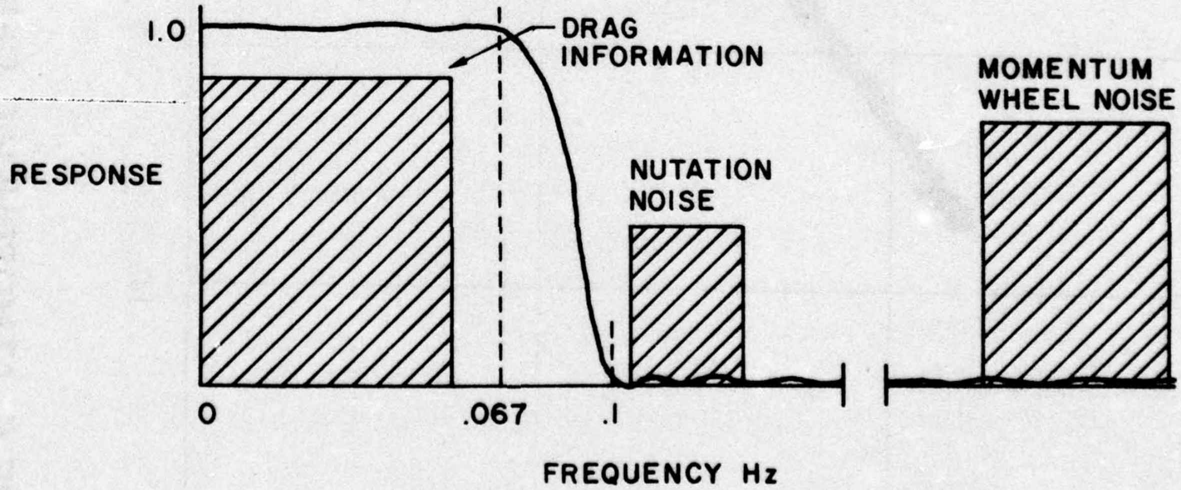


Figure 4. Filter '15 — 10' Response Curve

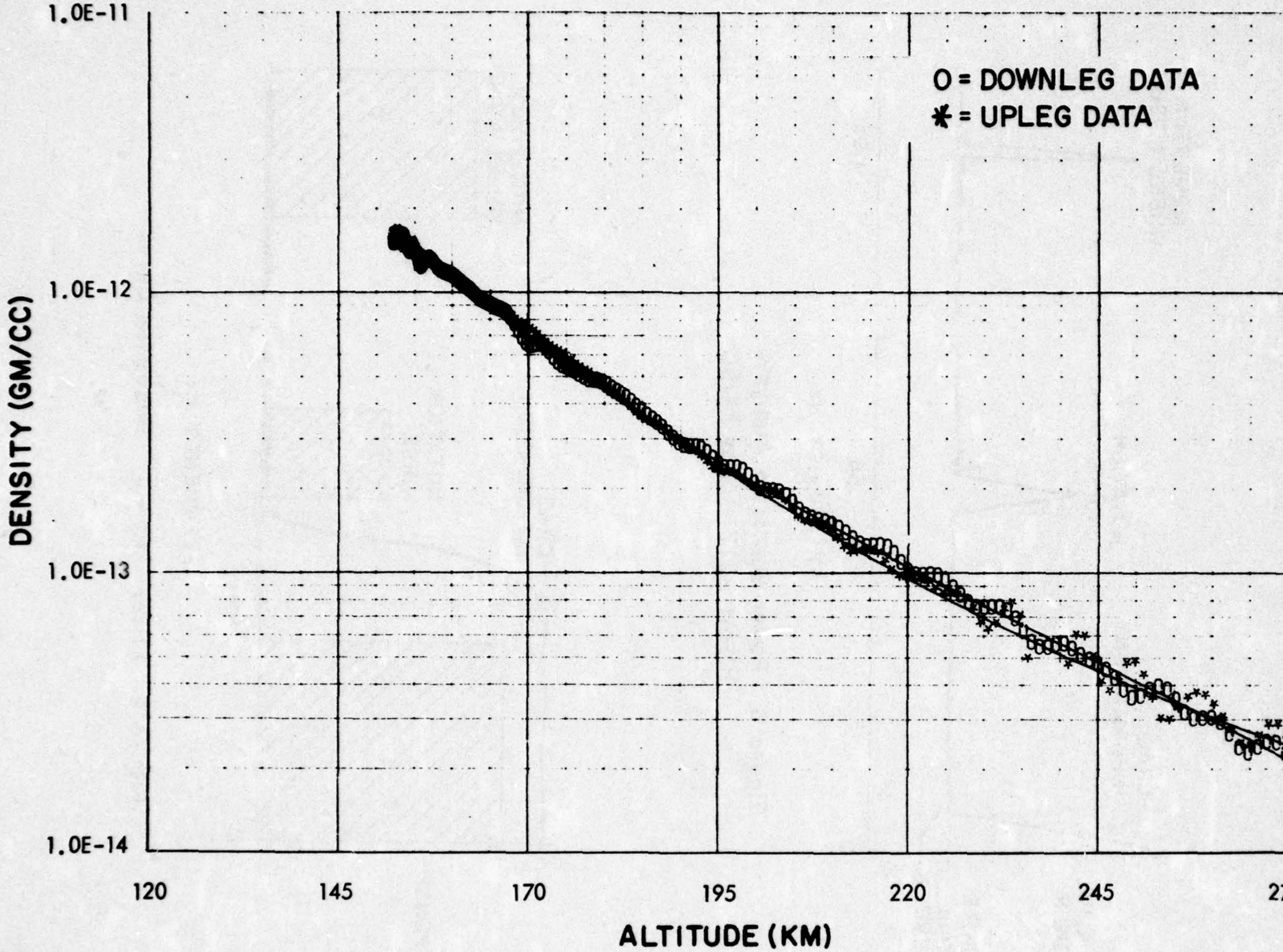


FIGURE 5. ATMOSPHERIC DENSITY DATA ORBIT 2217 DAY 74180 DESPUN

in the despun mode, nutation accelerations average about 1.8×10^{-4} g's, per degree of nutation on the MESA XY sensor.

Momentum wheel related accelerations for the most part again appear as high frequency modulations at 0.6 - 0.8 Hz with amplitudes averaging about 8×10^{-6} g's. In addition, accelerations due to movement of other sensors sometimes appear at frequencies lower than the spin frequency, typically about 0.033 Hz.

Figure 6 displays typical output data from MESA on orbit 2437 when the satellite was spinning at 0.067 Hz. Power spectrum analysis results from the XY sensor data are shown in Figure 7. Drag information is displayed as increased power at the spin frequency, with nutation effects and momentum wheel noise indicated.

To extract drag information from the total MESA signal in the spinning mode, a "band-pass" filter was designed with the characteristics shown in Figure 8. This filter removes (a) unwanted nutation accelerations which appear at about 0.102 Hz, (b) some motions of other instruments at about 0.033 Hz, (c) bias and centripetal accelerations appearing near DC, and (d) momentum wheel noise at 0.6 - 0.8 Hz. At the same time it is centered at 0.067 Hz to allow atmospheric drag information to pass.

The filter parameters were chosen to ensure that the filter would describe the maximum variation in atmospheric drag by passing the drag signal information, centered at the satellite spin frequency, having a bandwidth within the filter bandwidth. That is, the drag signal bandwidth is within .013 Hz of DC before modulation by the spin frequency.

The spectrum of this drag signal after spin modulation will reside within the filter bandwidth. At the same time all non-atmospheric noise accelerations at frequencies of less than 0.05 Hz and greater than 0.1 Hz will be removed by the filter.

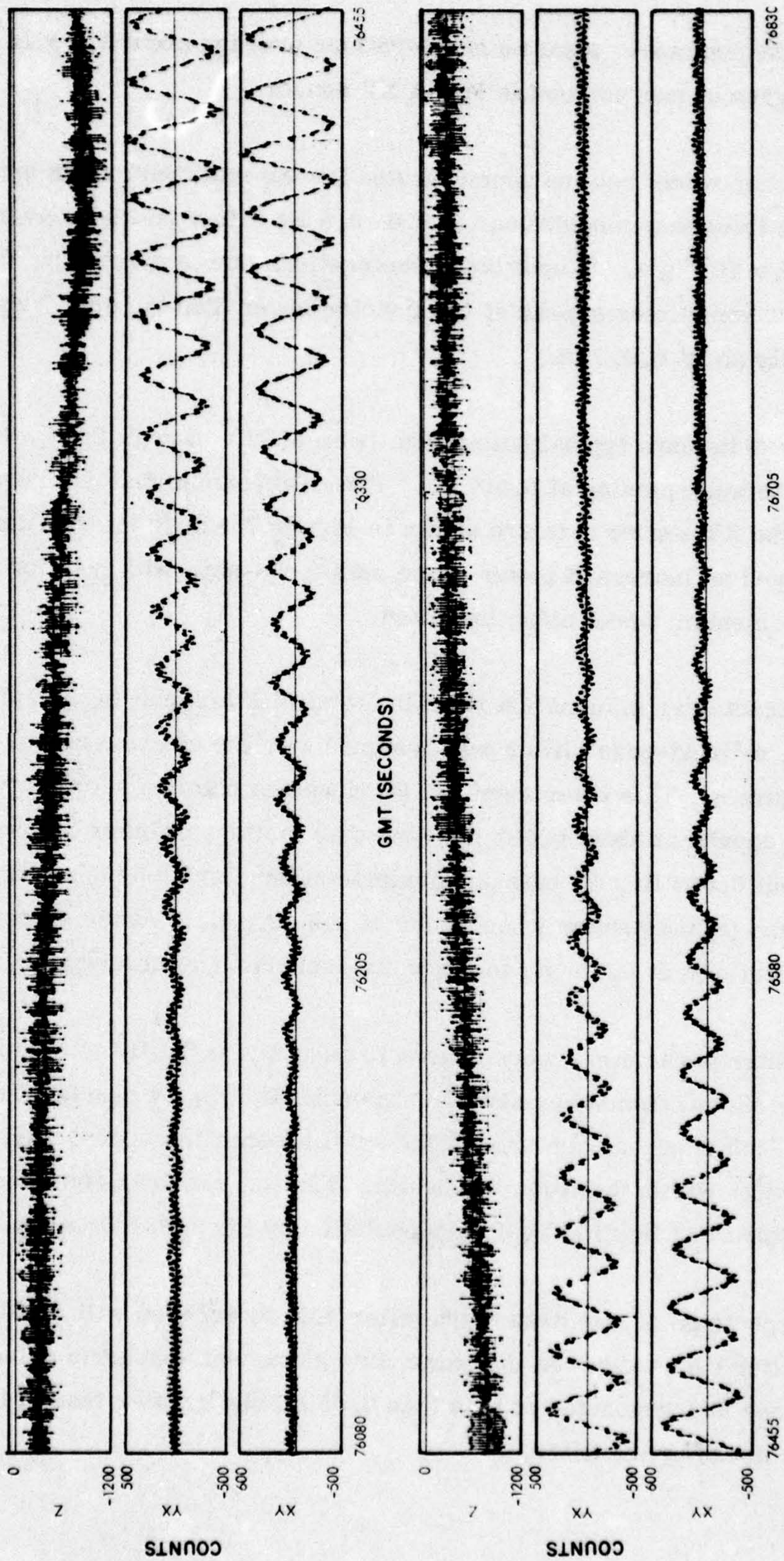


FIGURE 6. RAW MESA DATA ORBIT 2437 DAY 74198 SPINNING

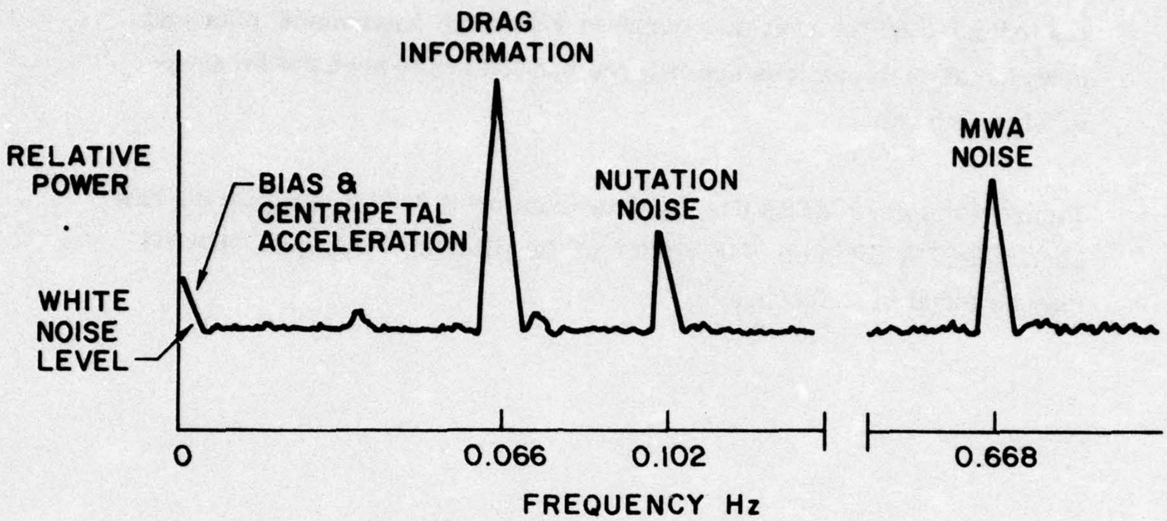


Figure 7. Power Spectrum Analysis
Orbit 2437 Day 74198

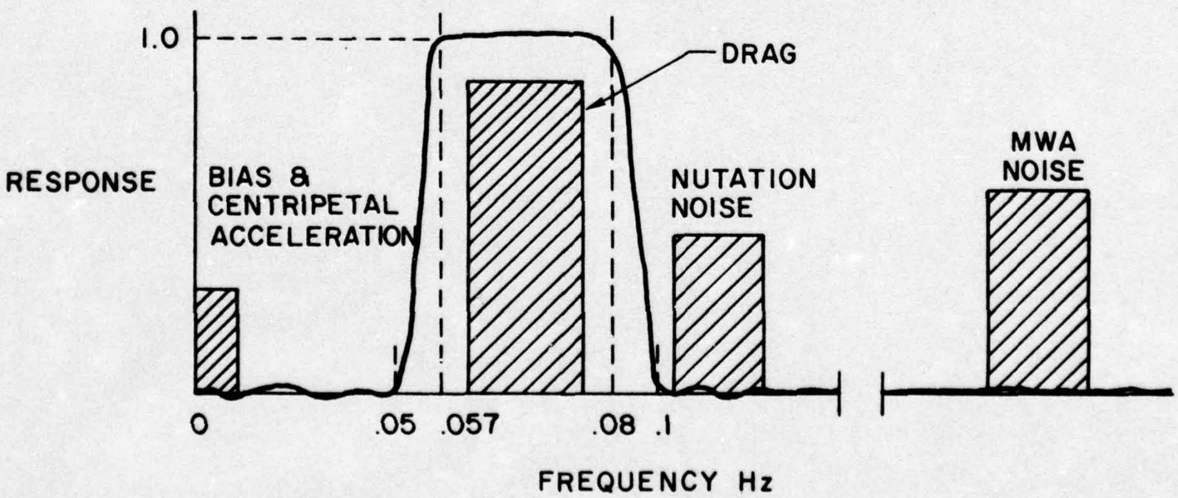


Figure 8. Band-Pass Filter

Since DC components are removed from the data by the bandpass filter (as indicated by the response curve in Figure 8) instrument bias and centripetal accelerations are filtered out and hence need not be separately removed.

Figure 9 displays MESA density data from orbit 2437 after filtering has been done. A complete description of the filtering techniques utilized may be found in Reference [4].

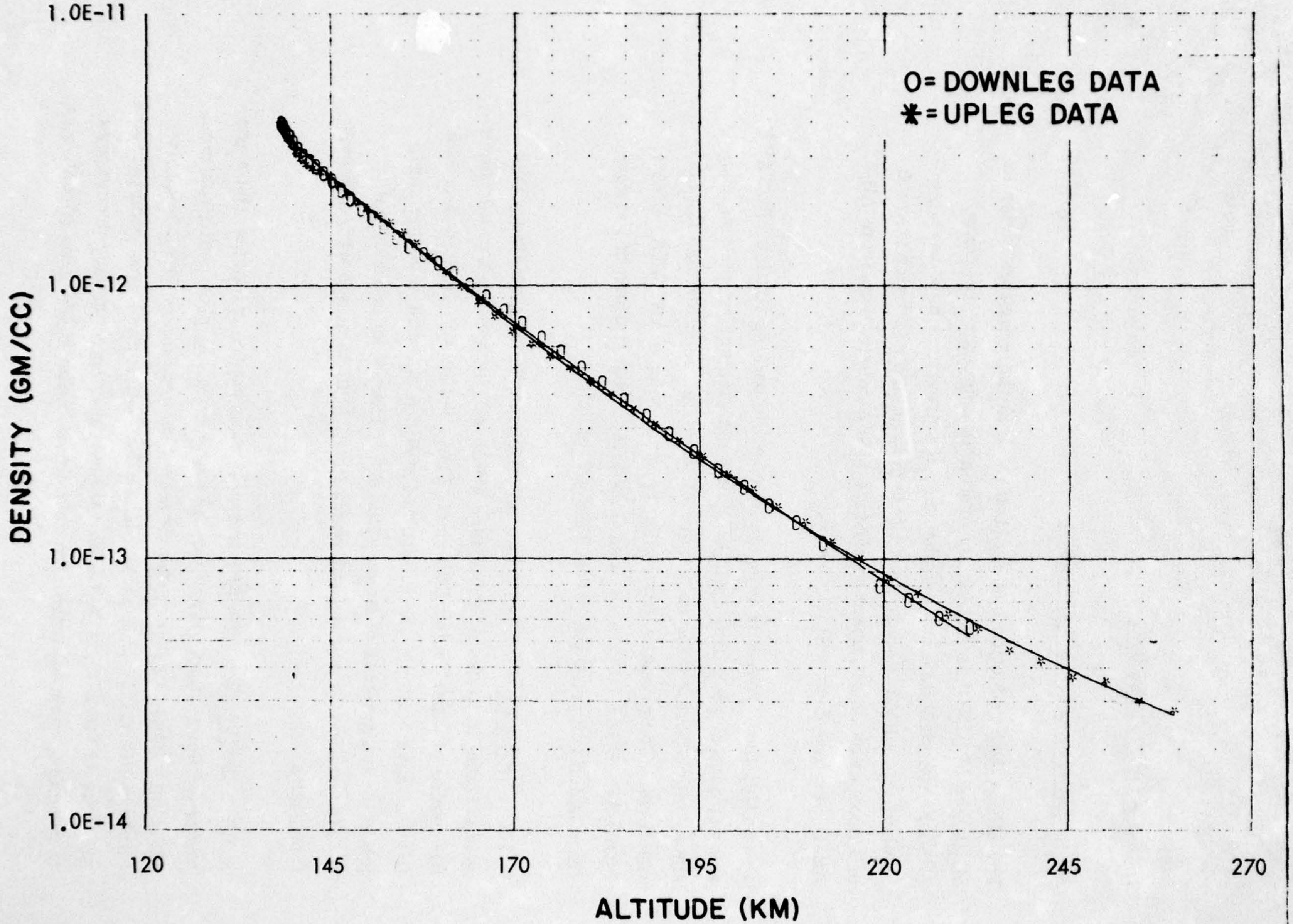


FIGURE 9. ATMOSPHERIC DENSITY DATA ORBIT 2437 DAY 74198 SPINNING

2. DATA PROCESSING

2.1 MESA Data Reduction System

The MESA data reduction system (DRS) was initially written (prior to the launch of AE-C) as an overlay system of computer programs. Although the structure has not changed, the programs have been periodically modified to their present forms and are now being utilized in a production environment to produce MESA density data from AE-C, AE-D, and AE-E on a timely basis.

Presently, the MESA DRS is made up of a file naming routine, ROTATE, a setup/control program, DRIVER9, and six primary processing routines, which perform the necessary MESA data reduction and display functions. The primary processing routines are: RAWDATA, DRAG, MODPAP, FILM, UAMAKE, and GUMAKE. Descriptions of the routines which comprise the MESA DRS are given.

2.1.1 ROTATE – ROTATE is a small preprocessing routine whose sole purpose is to generate suffixes which will be appended to all output file names of a particular DRS run. These suffixes guarantee that each file will have a unique name. ROTATE allows for either (a) the same job to be run a series of times without any loss of valuable output, or (b) simultaneously running two executions of the same job with different input data.

2.1.2 DRIVER9 – DRIVER9 is a setup and control program which generates namelist input values for the primary MESA processing routines, utilizing as input user-created directive records called Orbit Request Cards (ORCs). Various parameters allow full control over each primary program in the DRS, with additional control over secondary processors to promote, demote, and/or remove the associated GU-files (Geophysical

Unit files). For every set of namelists generated, a corresponding report is written, listing any errors detected and any actions taken.

There are two types of ORC parameters, Telemetry (TM) and Geophysical Unit (GU). Telemetry parameter sets are used to process data from the telemetry data file and usually indicate default processing from raw telemetry data to final density values. The form of the TM parameter syntax is:

SDATE, STIME, EDATE, ETIME [,SATID]

and is broken down as follows:

SDATE 5-digit Julian start date of data to be processed, form YYDDD.
STIME 8-digit start time of data, in milliseconds, range 0-86399999.
EDATE 5-digit Julian stop date of data. If 00000, assumed to be the same as SDATE.
ETIME 8-digit stop time of data, in milliseconds.
SATID 1-character satellite identifier, either C, D, or E. This parameter is optional. If omitted, the default SATID is E.

Geophysical Unit (GU) parameter sets are used to process data from MESA GU-files, that is, data which has been previously processed in some form. The form of the GU parameter syntax is: *GU ("file name") followed by any options and/or special requests which need be made. Default processing is from pre-processed temperature corrected MESA data to final density values.

Figure 10 illustrates both TM and GU parameter requests. The first two requests are for TM data to be processed for day 74198 (that is,

```
*MESA     TYPE I PRODUCTION AND TYPE II SUPPORT.     VERSION 2.8


********** TYPE I REQUESTS

 1.  74198 75540000 74198 77705000 *UAMAKE,*FILM:DEN,*GUMAKE

 2.  74198 40340000 74198 42545000 *UAMAKE,*FILM:DEN,*GUMAKE

 3.      0        0       0        0 *GU(A4199000) *UAMAKE,*GUMAKE,*FILM:DEN

 4.      0        0       0        0 *GU(A4199200) *UAMAKE,*GUMAKE,*FILM:DEN


    NO SEARCH HAS BEEN MADE TO ASCERTAIN WHETHER A GU-FILE ALREADY EXISTS WITH THE SAME NAME.
    CREIT:  2432      STATUS: DESPUN         STIME: 40340000     ETIME: 42545000     SDATE: 74198     EDATE: 74198
                      STIME USED: 40412000
                      ETIME USED: 42212000          PERIGEE: 41312000          GU-FILE: MESA.A4198110

    NO SEARCH HAS BEEN MADE TO ASCERTAIN WHETHER A GU-FILE ALREADY EXISTS WITH THE SAME NAME.
    CREIT:  2437      STATUS: SPINNING       STIME: 75540000     ETIME: 77705000     SDATE: 74198     EDATE: 74198
                      STIME USED: 75727605
                      ETIME USED: 77127605          PERIGEE: 76427605          GU-FILE: MESA.A4198210

    NO SEARCH HAS BEEN MADE TO ASCERTAIN WHETHER A GU-FILE ALREADY EXISTS WITH THE SAME NAME.
    SUBMITTED VIA MESA GROUP AT "AFCRL"...
    CREIT:  2439      STATUS: DESPUN         STIME:        0     ETIME:  6000000     SDATE: 74199     EDATE: 74199
                      STIME USED:        0
                      ETIME USED:  6000000          PERIGEE:  4063000          GU-FILE: MESA.A4199000

    NO SEARCH HAS BEEN MADE TO ASCERTAIN WHETHER A GU-FILE ALREADY EXISTS WITH THE SAME NAME.
    SUBMITTED VIA MESA GROUP AT "AFCRL"...
    CREIT:  2450      STATUS: SPINNING       STIME: 72000000     ETIME: 78000000     SDATE: 74199     EDATE: 74199
                      STIME USED: 72000000
                      ETIME USED: 78000000          PERIGEE: 74274000          GU-FILE: MESA.A4199200


**  NAME-LIST GENERATOR, VERSION 2.8  BATCH SUPPORT
 4 NAMELIST(S) WRITTEN.
```

Figure 10.   Report Page Generated by DRIVER 9

17 July 1974) with the GUMAKE, UAMAKE, and FILM primary routines to be executed as well as the default routines RAWDATA, DRAG, and MODPAP.

Requests 3 and 4 are for GU data to be processed from the files specified. For all four requests namelist input values will be generated for the primary processing routines to read, and descriptions of the orbits which these requests will process are given.

The remaining routines are the primary processing routines of the MESA DRS. Following is a list of each routine and the types of input and output files – telemetry (TM) geophysical unit (GU) and unified abstract (UA) – which each requires:

Name	Input	Output
RAWDATA	TM	GU
DRAG	GU	GU
MODPAP	GU	GU
FILM	GU	film plots
UAMAKE	GU	UA
GUMAKE	GU	GU

Following is a brief description of each routine.

2.1.3 RAWDATA – RAWDATA reads the telemetry file, extracts all MESA information for those times when the satellite is below 700 kilometers, determines on/off and sensitivity status, constructs MESA sensor outputs from the TM words, determines accelerometer temperatures and temperature-corrects measured data, edits erroneous data values, replaces missing data values, calculates appropriate orbit/attitude information, and outputs these data to a GU file for use by other primary programs.

Printer output from RAWDATA includes accelerometer temperature information, satellite and momentum wheel spin rates, and various statistical values describing the quality of the TM data processed by this program.

Figure 11 is an example of the two page printer report generated by RAWDATA.

2.1.4 DRAG – This routine is the major processing program of the DRS, and it requires as input the GU file created by RAWDATA. DRAG extracts atmospheric drag information from the temperature-corrected data by utilizing various digital filters and/or data modelling techniques, calculates atmospheric density values by one of the methods described in Section 1.3, determines any transverse wind components, and stores this information back on the GU file.

In addition, DRAG has the capability of calculating attitude information utilizing the MESA output data. This is done periodically to test the accuracy of the spacecraft attitude system.

Printer output from DRAG includes calculated instrument bias values, MESA on/off and range status and coefficients of a least squares fit done to the calculated density data. These coefficients will later be used to generate a printer plot display of the density versus altitude profile for the particular orbit processed.

Figure 12 illustrates the one page printer report generated by DRAG.

2.1.5 MODPAP – MODPAP requires the GU file created by DRAG as input to perform its three main functions. It:

(a) calculates and stores (in the GU file) Jacchia 71 model atmosphere density values,

```
***** RAWDATA IS HERE VER. 1.1.9 *****
FILE NAME IS: MSSA.A8159218                  ***AE-C***


IDELAY = 85
                                                                                 MWA SPEED
                                                                              SECONDS     HZ
                                                                                .294     3.399

                                                                                 MWA NOISE
                                                                              SECONDS     HZ
                                                                               1.665     .601

                                                                                BODY SPEED
                                                                              SECONDS     HZ
                                                                                .338     .748
                     AE-C    DATE OF DATA 74196      ORBIT  2927      SPINNING             DATE OF RUN 76266

                                          TEMPERATURES

           TIME       XY TEMP             TIME      YX TEMP             TIME      Z TEMP
         MILLISEC     DEG F             MILLISEC    DEG F             MILLISEC    DEG F

         75955759     59.10             75955812    60.12             75955975    55.30
         76275751     60.29             76275812    60.70             76275975    60.50
         76595759     60.56             76595812    61.28             76595975    61.10
         76915759     61.19             76915812    61.86             76915975    61.73

            COEFFICIENTS OF XY TEMPERATURE FIT: -246.93338013     .00402830
            COEFFICIENTS OF YX TEMPERATURE FIT: -191.61152649     .00332529
            COEFFICIENTS OF Z  TEMPERATURE FIT: -167.26274139     .00296849


RAW    DATA EDIT STATISTICS

      EDIT TEST VARIABLE =  6.00

      NO. OF XY POINTS EDITED     0  0  0  0  0  4  2  0  0  0  0  2  0  0  2  0  0  2  0  0  0  0  0  0
      NO. OF YY POINTS EDITED     2  0  0  0  0  0  0  0  2  0  0  0  0  2  0  0  0  0  0  0  0  0  0  0
      NO. OF Z  POINTS EDITED     0  0  0  0  0  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  2  0  0


      NO. OF XY POINTS EDITED     0  0  0  3  0
      NO. OF YX POINTS EDITED     0  0  0  2  0
      NO. OF Z  POINTS EDITED     0  0  0  0  0
HEADMAKE HERE
 DIRECTORY HERE
1
```

Figure 11.   Two-page Printer Report Generated by RAWDATA

```
RAW DATA STATISTICS FOR AE-C     DATE OF DATA 74199     ORBIT  2437     SPINNING                    DATE OF RUN 76266

NUMBER OF POINTS EDITED          XY:      12
                                 YX:       6
                                 Z :       4

NUMBER OF QUALITY FLAGS  SET     XY:      19
                                 YX:       6
                                 Z :       6

NUMBER OF FILL FRAMES            XY:       6
                                 YX:       4
                                 Z :       2

NUMBER OF SATURATED FRAMES       XY:       0
                                 YX:       0
                                 Z :       0

NUMBER OF FRAMES IN OVERRANGE    XY:       3
                                 YX:       2
                                 Z :       3

NUMBER OF MISSING MAJOR FRAMES   :         0

NUMBER OF QUESTIONABLE BYTES               0

START TIME USED:                  75555166
END TIME USED:                    77126811
NUMBER OF DATA SETS:                  4669
TIME INCREMENT USED:                   250
TIME INCREMENT CALCULATED:         249.977

                                          SUCCESSFUL RUN -- DO NOT RERUN DATA
*****     RAWDATA SAYS GOODBYE     *****
```

Figure 11.   Two-page Printer Report Generated by RAWDATA (Cont.)

```
**** DRAG IS HERE ****
FILE NAME IS: MESA.A4158210              .***AE-C***

              RMASS=1405.60

                                               SPIN RATE IS   15.22 SEC

        ***DOWNLEG BIAS DATA*******UPLEG   BIAS DATA***
        *    TIME       BIAS PTS    TIME       BIAS PTS*
        *       0        .00  0        0        .00  0 *
        ***********************************************

                                                                      RUN DATE 76266

                             DRAG STATISTICS

              ORBIT  2437      DATE OF ORBIT 74198      SATELLITE SPINNING

                                MESA STATUS
                 XY                 YX                   Z
                 ON                 ON                   ON
              CONSTRAINMENT = B   CONSTRAINMENT = B   CONSTRAINMENT = C
              SUSPENSION = B      SUSPENSION = B      SUSPENSION = C

                             FILTER PARAMETERS
                               NFILT    240
                               FS3      2.45
                               FS4      2.55

                                DENSITY CALCULATED BY
                                     YX/ASPECT
                              WINDS NOT CALCULATED

              NUMBER OF COSINE RAM POINTS:     100
              NUMBER OF RAM POINTS IN FIT:      95

              DOWNLEG COEFFICIENTS: -.74495E 01 -.34373E-01  .40067E-04  .00000E 00 -.00000E 00
              UPLEG COEFFICIENTS  : -.70657E 01 -.39012E-01  .53642E-04  .00000E 00 -.00000E 00

                Z AVERAGE APOGEE VALUE :  .00000E 00      0 POINTS USED
              START TIME OF DENSITY FIT:   76096079
              STOP TIME OF DENSITY FIT :   76808566

HEADMAKE HERE
 DIRECTORY HERE
**********DRAG SAYS GOODBYE**********
```

Figure 12. One-page Printer Report Generated by DRAG

(b) provides various printer plot displays of MESA generated atmospheric parameters,

(c) generates a comprehensive listing of particular orbit, attitude, and MESA generated parameters.

Figure 13 displays the report generated by the MODEL section of MODPAP. An example of the printer plot density profile which may be generated by MODPAP is given in Figure 14. Figure 2 (Section 1.3) is an example of a raw data printer plot displayed as a function of GMT. Figure 15 (two pages) illustrates the type of report generated by the GU-list section of MODPAP.

2.1.6 UAMAKE – UAMAKE reads the density values generated by DRAG from the GU-file and writes density and/or wind values into their proper position in the Unified Abstract (UA) file for use by other experimenters. Since UA data is stored at exact 15-second intervals by all experiments, UAMAKE performs interpolating functions to generated density values at the required times.

Printer output from UAMAKE is a listing of MESA generated density values at the required UA times.

Figure 16 displays the printer report generated by the UAMAKE routine.

2.1.7 GUMAKE – The main function of GUMAKE is to compact the GU file created by the other primary processing routines into files (called B-files) suitable for tape storage.

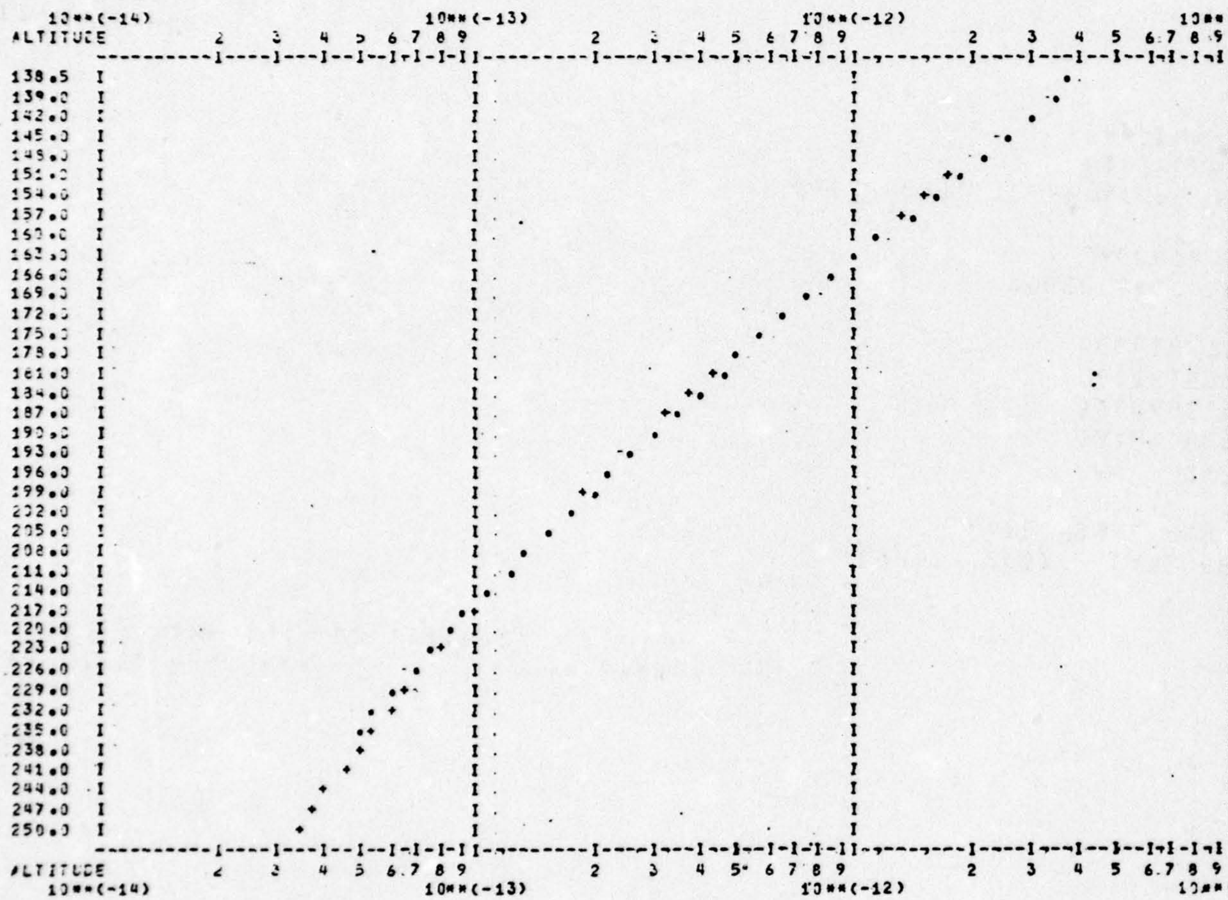
The B-files contain only essential MESA data – temperature-corrected acceleration counts, derived density values and the associated GMT time tags.

It should be noted that should the need arise, the primary routines have the capability of reading this B-file as input to perform their tasks.

```
*** MODEL HERE ***                  ***AE-C***
    FILE NAME IS: MESA.A4198210

                                                   ORBIT   2437    DATE OF ORBIT 74198
                                                           DATE MODEL RUN 76260

                                                                KR=    2.3
                                                                DAILY FLUX(F7)=      88.0
                                                                AVERAGE FLUX(FB7)=      89.1
                                                                MODIFIED JULIAN DAY=      42245
                                                                DECLINATION OF SUN=   21.154

                                                            MODEL CALCULATED BY
                                                                JACCHIA 71 MODEL

                                                 EXOSPHERIC TEMPERATURE RANGE FOR THIS DATA
                                                                MINIMUM=      731.0
                                                                MAXIMUM=      795.4

HEADMAKE HERE
 DIRECTORY HERE
     ***** MODEL DONE *****
1
```

Figure 13.   Printer Report Generated by the Model Section of MODPAP

```
***PAPER PLOTS HERE LAST UPDATE 8/9/75/***
FILE NAME IS: MESA.A4193210              ***AE-C***
                         PREPARED BY R.D.P. INC.
             IN SUPPORT OF THE MESA ACCELEROMETER DATA ANALYSIS PLAN

   FILE NAME = MESA.A4193210   ORBIT NO. = 2437   DATE = 74198        DRAG RUN DATE 76266

     PERIGEE DATA                        FILTER PARAMETERS            YX/ASPECT
       TIME= 76428323                      NFILT   240                SPINNING
       LATITUDE=       25.8                FS3     2.4
       LONGITUDE=      29.                 FS4     2.6
       ALTITUDE=     138.50                FS3Z   33.0  FS3XY 15.0
                                           FS4Z   20.0  FS4XY 10.0
                                                                      + = UPLEG
                                                                      . = DOWNLEG
                     GRAPH OF DENSITY VS ALTITUDE
```



ALT	DENSITY UPLEG	DENSITY DOWNLEG
138.5	3.61E-12	3.62E-12
139.0	3.51E-12	3.52E-12
142.0	2.98E-12	3.00E-12
145.0	2.53E-12	2.56E-12
148.0	2.15E-12	2.19E-12
151.0	1.94E-12	1.88E-12
154.0	1.57E-12	1.61E-12
157.0	1.35E-12	1.39E-12
160.0	1.16E-12	1.19E-12
163.0	9.96E-13	1.03E-12
166.0	8.59E-13	8.89E-13
169.0	7.43E-13	7.69E-13
172.0	6.44E-13	6.66E-13
175.0	5.60E-13	5.79E-13
178.0	4.87E-13	5.03E-13
181.0	4.25E-13	4.33E-13
184.0	3.72E-13	3.82E-13
187.0	3.26E-13	3.34E-13
190.0	2.86E-13	2.92E-13
193.0	2.52E-13	2.56E-13
196.0	2.22E-13	2.25E-13
199.0	1.96E-13	1.98E-13
202.0	1.74E-13	1.75E-13
205.0	1.55E-13	1.54E-13
208.0	1.38E-13	1.36E-13
211.0	1.23E-13	1.21E-13
214.0	1.10E-13	1.07E-13
217.0	9.84E-14	9.51E-14
220.0	8.83E-14	8.47E-14
223.0	7.95E-14	7.55E-14
226.0	7.17E-14	6.74E-14
229.0	6.49E-14	6.03E-14
232.0	5.88E-14	5.40E-14
235.0	5.34E-14	4.85E-14
238.0	4.86E-14	
241.0	4.43E-14	
244.0	4.05E-14	
247.0	3.71E-14	
250.0	3.41E-14	

Figure 14. Printer Plot Density Profile Generated by MODPAP

```
***GULIST TYPE A FILE HERE***
FILE NAME IS: MESA.A4198210                    ***AE-C***

                         AE-C
              ORBIT  2437    DATE 74198

              ORBITAL DATA
                   PERIOD=    116.893
                   INCLINATION=      68.098
                   ECCENTRICITY=        .176
                   SEMI-MAJOR AXES=  7919.328
                   ARGUMENT OF PERIGEE=     27.633
                   R.A. OF ASCENDING NODE=   271.750
                   SATELLITE SPINNING

              DENSITY CALCULATED BY
                   YX/ASPECT

              MODEL DENSITY USED
                   JACCHIA 71 MODEL

              PERIGEE DATA
                   TIME= 75428323
                   LATITUDE=        25.8
                   LONGITUDE=         29.
                   ALTITUDE=    138.50

              FILTER PARAMETERS
                   NFILT    240
                   FS3        2.4
                   FS4        2.5

                            MESA STATUS
         XY                      YX                      Z
         ON                      ON                      ON
CONSTRAINMENT = B        CONSTRAINMENT = B       CONSTRAINMENT = C
SUSPENSION = B           SUSPENSION = B          SUSPENSION = C

           START DATE 74198      START TIME 75727605
           END DATE 74198      END TIME 77127605

                                                      RUN DATE 76266
                                                      SATELLITE ATTITUDE
```

1

Figure 15. Printer Report Generated by the GU-list Section of MODPAP

RUN DATE 76266
RAM POINTS.

SATELLITE AE-C
ORBIT 2437 DATE 74198

GMT X1000	ALT KM	LAT	LON +E	LOCAL H	M	S	COS XY	COS YX	COS Z	FM XY	FC XY	FM YX	FC YX	FM Z	FC Z	DRAG XY	DRAG YX	DRAG Z	DENSITY GM/CC	RATIO	WIND M/S	F.
76086079	235.9	1	19	22	26	0	39	995	76	8	8	71	72	-410	-413	.0E 00	9.6E-07	.0E 00	4.80E-14	.94	0	
76093579	231.7	2	19	22	27	0	4	996	76	73	73	52	53	-493	-496	.0E 00	-1.1E-06	.0E 00	5.62E-14	.97	0	
76101329	227.5	2	20	22	28	0	52	994	76	21	21	65	66	-205	-206	.0E 00	1.2E-06	.0E 00	6.21E-14	.94	0	
76108829	223.5	3	20	22	29	0	.6	996	76	2	2	59	59	-159	-160	.0E 00	-1.4E-06	.0E 00	7.04E-14	.94	0	
76116329	219.6	3	20	22	30	0	35	995	76	18	18	54	54	-162	-163	.0E 00	1.6E-06	.0E 00	7.99E-14	.94	0	
76124078	215.6	4	20	22	30	0	18	996	76	15	15	-22	-22	-454	-457	.0E 00	-2.0E-06	.0E 00	9.73E-14	1.00	0	
76131573	211.9	4	20	22	31	0	23	995	76	13	13	-26	-26	-607	-611	.0E 00	2.3E-06	.0E 00	1.15E-13	1.04	0	
76139328	208.1	5	20	22	32	0	31	996	76	76	76	-66	-67	-87	-87	.0E 00	-2.8E-06	.0E 00	1.37E-13	1.09	0	
76146828	204.5	5	21	22	33	0	10	995	76	64	64	6	6	-542	-546	.0E 00	3.2E-06	.0E 00	1.57E-13	1.11	0	
76154579	201.0	6	21	22	34	0	44	995	76	109	110	-32	-32	-205	-206	.0E 00	-3.7E-06	.0E 00	1.83E-13	1.13	0	
76162079	197.6	6	21	22	34	0	.0	995	76	69	69	40	40	-292	-294	.0E 00	4.3E-06	.0E 00	2.11E-13	1.16	0	
76169578	194.3	7	21	22	35	0	43	996	76	56	56	-10	-10	-282	-284	.0E 00	-5.0E-06	.0E 00	2.47E-13	1.20	0	
76177328	191.0	8	21	22	36	0	13	995	76	64	64	99	100	-650	-655	.0E 00	5.9E-06	.0E 00	2.88E-13	1.23	0	
76184827	187.9	8	22	22	37	0	30	996	76	55	55	20	20	-586	-590	.0E 00	-6.8E-06	.0E 00	3.33E-13	1.25	0	
76192577	184.8	9	22	22	38	0	26	995	75	17	17	76	77	-423	-426	.0E 00	7.8E-06	.0E 00	3.84E-13	1.27	0	
76200077	181.9	9	22	22	39	0	18	996	75	32	32	-24	-24	-345	-347	.0E 00	-8.9E-06	.0E 00	4.38E-13	1.29	0	
76207827	179.0	10	22	22	40	0	39	995	75	-2	-2	92	93	-257	-259	.0E 00	1.0E-05	.0E 00	5.02E-13	1.31	0	
76215327	176.3	10	22	22	41	0	4	996	75	-7	-7	-43	-43	-258	-260	.0E 00	-1.2E-05	.0E 00	5.72E-13	1.32	0	
76223077	173.6	11	22	22	41	0	52	994	75	61	62	51	51	-463	-466	.0E 00	1.3E-05	.0E 00	6.46E-13	1.32	0	
76230577	171.1	11	23	22	42	0	6	996	75	53	53	-122	-123	-724	-729	.0E 00	-1.5E-05	.0E 00	7.25E-13	1.32	0	
76238076	168.6	12	23	22	43	0	35	995	75	59	59	51	51	-539	-543	.0E 00	1.6E-05	.0E 00	8.09E-13	1.31	0	
76245826	166.2	12	23	22	44	0	18	996	75	69	69	-137	-139	-292	-294	.0E 00	-1.9E-05	.0E 00	9.07E-13	1.31	0	
76253326	164.0	13	23	22	45	0	22	995	75	86	86	104	105	-353	-355	.0E 00	2.1E-05	.0E 00	1.01E-12	1.30	0	
76261076	161.7	13	23	22	46	0	32	996	75	88	88	-75	-76	-600	-604	.0E 00	-2.3E-05	.0E 00	1.11E-12	1.29	0	
76268576	159.7	14	24	22	47	0	.9	995	75	101	101	204	207	-764	-769	.0E 00	2.5E-05	.0E 00	1.21E-12	1.26	0	
76276326	157.7	14	24	22	48	0	45	995	75	4	4	-96	-97	-630	-634	.0E 00	-2.6E-05	.0E 00	1.30E-12	1.21	0	
76283826	155.8	15	24	22	49	0	2	996	74	5	5	199	201	-510	-513	.0E 00	2.8E-05	.0E 00	1.39E-12	1.17	0	
76291325	154.0	15	24	22	49	0	42	996	74	41	41	-129	-130	-673	-678	.0E 00	-3.1E-05	.0E 00	1.50E-12	1.14	0	
76299075	152.3	16	24	22	50	0	15	995	74	34	34	212	215	-457	-460	.0E 00	3.3E-05	.0E 00	1.64E-12	1.13	0	
76306575	150.8	16	25	22	51	0	29	996	74	-1	-1	-157	-159	-386	-386	.0E 00	-3.6E-05	.0E 00	1.78E-12	1.12	0	
76314325	149.2	17	25	22	52	0	28	995	74	26	26	175	177	-814	-820	.0E 00	3.9E-05	.0E 00	1.92E-12	1.11	0	
76321825	147.8	17	25	22	53	0	15	996	74	17	17	-250	-253	-940	-947	.0E 00	-4.3E-05	.0E 00	2.07E-12	1.09	0	
76329575	146.5	18	25	22	54	0	41	995	74	93	93	250	253	-627	-631	.0E 00	4.6E-05	.0E 00	2.25E-12	1.09	0	
76337075	145.3	19	25	22	55	0	2	997	74	75	75	-258	-261	-740	-745	.0E 00	-5.0E-05	.0E 00	2.42E-12	1.09	0	
76344825	144.2	19	26	22	56	0	54	994	73	76	76	340	344	-930	-906	.0E 00	5.3E-05	.0E 00	2.60E-12	1.08	0	
76352324	143.1	20	26	22	57	0	.7	997	73	41	41	-246	-249	-766	-771	.0E 00	-5.6E-05	.0E 00	2.74E-12	1.06	0	
76359824	142.2	20	26	22	58	0	35	995	73	86	86	333	337	-648	-652	.0E 00	5.9E-05	.0E 00	2.86E-12	1.04	0	
76367574	141.4	21	26	22	59	0	18	996	73	60	60	-278	-282	-889	-895	.0E 00	-6.2E-05	.0E 00	3.01E-12	1.03	0	
76375074	140.7	21	26	23	0	0	24	995	73	73	73	432	438	-1062	-1070	.0E 00	6.5E-05	.0E 00	3.18E-12	1.03	0	
76382824	140.0	22	27	23	1	0	28	996	73	26	26	-337	-343	-746	-751	.0E 00	-6.9E-05	.0E 00	3.37E-12	1.05	0	
76390324	139.5	22	27	23	2	0	14	996	72	9	9	441	447	-844	-850	.0E 00	7.3E-05	.0E 00	3.54E-12	1.06	0	
76398074	139.1	23	27	23	3	0	39	996	72	42	42	-400	-405	-809	-815	.0E 00	-7.6E-05	.0E 00	3.69E-12	1.07	0	
76405573	138.8	23	27	23	4	0	3	996	72	80	80	436	442	-784	-789	.0E 00	7.9E-05	.0E 00	3.81E-12	1.08	0	
76413323	138.5	24	27	23	5	0	50	995	72	57	57	-472	-478	-1155	-1163	.0E 00	-8.0E-05	.0E 00	3.90E-12	1.09	0	
76420823	138.4	24	28	23	6	0	6	996	72	48	48	389	394	-796	-801	.0E 00	8.1E-05	.0E 00	3.94E-12	1.08	0	
76428323	138.4	25	28	23	7	0	38	996	71	15	15	-484	-490	-1178	-1186	.0E 00	-8.1E-05	.0E 00	3.93E-12	1.08	0	
76436073	138.5	25	28	23	8	0	19	996	71	76	76	432	438	-863	-869	.0E 00	7.9E-05	.0E 00	3.86E-12	1.07	0	
76443573	138.7	26	28	23	9	0	24	996	71	62	62	-456	-462	-689	-694	.0E 00	-7.7E-05	.0E 00	3.75E-12	1.05	0	
76451323	138.9	26	29	23	10	0	34	995	71	41	41	452	458	-869	-875	.0E 00	7.4E-05	.0E 00	3.61E-12	1.04	0	
76458823	139.3	27	29	23	11	0	9	997	71	56	56	-376	-381	-870	-876	.0E 00	-7.1E-05	.0E 00	3.46E-12	1.02	0	
76466572	139.8	27	29	23	12	0	48	995	70	32	32	404	409	-911	-917	.0E 00	6.7E-05	.0E 00	3.29E-12	1.00	0	
76474072	140.4	28	29	23	13	0	.3	997	70	43	43	-275	-278	-795	-800	.0E 00	-6.3E-05	.0E 00	3.09E-12	.98	0	
76481572	141.0	28	30	23	14	0	36	995	70	68	68	392	397	-787	-792	.0E 00	6.0E-05	.0E 00	2.91E-12	.97	0	

Figure 15. Printer Report Generated by the GU-list Section of MODPAP (Cont.)

```
*** UAMAKE HERE ***
FILE NAME IS : MESA.AH198210
      ****E-C***
                          UNIFIED ABSTRACT FILE GENERATION REPORT

            ORBIT   2437       DATE 74198       DRAG RUN DATE 76266            DATE. OF RUN. 76266

                                                 NFILT     240
      PERIGEE TIME    76428323                   FS3       2.45
      UASTART TIME    76036079                   FS4       2.55
      UASTOP  TIME    76808566                   FS37     33.00
                                                 FS47     28.00
```

KLM = 94

TIME	ALTITUDE	DENSITY
76095000	230.91	5.75E-14
76110000	222.85	7.20E-14
76125000	215.14	9.97E-14
76140000	207.79	1.39E-13
76155000	200.78	1.84E-13
76170000	194.14	2.48E-13
76185000	187.67	3.35E-13
76200000	181.96	4.39E-13
76215000	176.42	5.69E-13
76230000	171.25	7.19E-13
76245000	166.46	8.97E-13
76260000	162.04	1.10E-12
76275000	158.00	1.28E-12
76290000	154.35	1.48E-12
76305000	151.07	1.75E-12
76320000	148.18	2.03E-12
76335000	145.62	2.37E-12
76350000	143.45	2.70E-12
76365000	141.66	2.96E-12
76380000	140.27	3.30E-12
76395000	139.26	3.64E-12
76410000	138.64	3.87E-12
76425000	138.41	3.94E-12
76440000	138.56	3.80E-12
76455000	139.11	3.54E-12
76470000	140.04	3.20E-12
76485000	141.36	2.34E-12
76500000	143.07	2.64E-12
76515000	145.16	2.43E-12
76530000	147.63	2.11E-12
76545000	150.49	1.87E-12
76560000	153.71	1.67E-12
76575000	157.28	1.39E-12
76590000	161.21	1.09E-12
76605000	165.52	8.42E-13
76620000	170.20	6.65E-13
76635000	175.24	5.42E-13
76650000	180.65	4.33E-13
76665000	186.43	3.47E-13
76680000	192.55	2.69E-13
76695000	199.04	2.04E-13
76710000	205.88	1.56E-13
76725000	213.07	1.16E-13
76740000	220.61	8.48E-14
76755000	228.48	6.37E-14
76770000	236.69	4.71E-14
76785000	245.23	3.81E-14

```
DIRECTORY HERE
    **** UAMAKE DONE ****
```

Figure 16. Printer Report Generated by UAMAKE

This capability alleviates the need to repromote TM data at some later date should a particular orbit of data require reprocessing.

2.1.8 FILM – The FILM routine provides the capability of displaying any combination of the following 35 mm (or 16 mm) film plots:

(a) raw MESA data displayed as a function of GMT,
(b) temperature-corrected edited MESA data as function of GMT,
(c) drag components as a function of GMT,
(d) atmospheric density as a function of altitude,
(e) ratio of measured density to model density as a function of altitude.

Input to this routine is the GU file generated by RAWDATA and DRAG. Figures 6 and 9 (Section 1.3) are examples of raw data and density plots generated by this routine.

2.2 MESA Utilities

In addition to the primary routines comprising the MESA DRS, there are three important programs which are being utilized daily to facilitate the processing and management of the MESA data system. A brief description of each follows.

2.2.1 DEMOTE – Because of extremely limited on-line storage, Geophysical Unit (GU) files must be demoted (i.e., copied) to magnetic tape. For obvious reasons it was desirable to group processed data orbits by satellite and subdivide each satellite by file type and reduction status on separate tapes. For this reason the MESA DEMOTE facility was developed.

Simply stated, as each DRS production job is processed the final step is to write the name of the output GU-file into a permanent on-line file called DEMOTELIST. The DEMOTE program when executed, reads the list of the GU-files to be demoted from DEMOTELIST. Then, utilizing information acquired from the Data Management Facility tape directory file and the MESA tape selection algorithm, the DEMOTE program sets up input files containing the names of files which are to be demoted. A listing is generated describing the decisions made and a report is written defining the tape base status.

The DEMOTE processor then demotes the GU-files to the tapes chosen, and the original DEMOTELIST file is reinitialized for future use. This program is exercised a few times a day, and it provides a reasonable method of maintaining on-line storage space for MESA processing.

2.2.2 WORKLIST – The WORKLIST facility is a self-batching processor used to satisfy most MESA DRS requests which are not processed by the NASA production service. It provides control over each MESA DRS' primary processing routine and GU-file management option, as

well as allows the user to directly access several system processors. WORKLIST builds a multitasking environment and is largely self-maintaining, continuing to run until it is explicitly stopped.

Two job control language (JCL) files support WORKLIST by batching invocations of each other. The control file is $:TASKS, which reads, interprets, and deletes the top job request from WORKLIST, runs DRIVER9 to prepare NAMELISTS for the MESA primary routines, promotes any GU-files required, batches the production job, $*TASK, and finally executes any processor invoked from the previous job-set. The production job maintains the WORKLIST thread by rebatching the setup job, $:TASKS to setup the next request, runs each routine in the MESA DRS, promoting and removing telemetry data when required, runs the various processors associated with GU-file disposition, and finally does clean-up operations to remove utility files associated with the setup/run job-pair.

To ensure that output files from separate WORKLIST jobs have different identifiers, each job pair utilizes a unique, 2-digit serial number. This number is updated each time $:TASKS is run, through MESA's ROTATE facility, which was described by Section 2.1.1.

The use of WORKLIST has greatly increased the processing capability of MESA personnel, while at the same time requiring minimal manual maintenance.

2.2.3 HEADHIST – Due to the large data reduction requirements of AE, the HEADHIST facility was written to provide an automatic logging system for all data as it is being processed by the MESA DRS. HEADHIST is a system of directory files containing two types of fixed length records, directory records and header records. For each satellite there is a separate file capable of storing up to 12,000 orbits of directory and header information.

The HEADHIST system is accessed through calls to three entry points:

(a) HEADHIST, which stores the header record data for each orbit processed,

(b) DIRECTORY, which updates the directory records as each primary routine is run,

(c) RESETDIR, which resets directory records if data are to be removed.

The HEADHIST files are read by other programs which provide a reasonable reporting system of the status and/or availability of reduced MESA data. Figure 17 is an example of one such report generated from the HEADHIST header record files. An example of other programs which access the HEADHIST files is a program which generates a listing of calculated bias values for each despun orbit processed by MESA. These bias data will be later used to study the performance of instrument bias over many months.

LISTING OF HEADER DATA FROM THE ATMOSPHERE EXPLORER-C SPACECRAFT

ORBIT NO.	S/C	ORBIT DATE	ACC STATUS XY	YX	ZZ	D E N	M N D	PERIGEE GMT	LST	DATA LAT	LONG	ALT	START TIME	DATA LAT	LNG	ALT	STOP TIME	DATA LAT	LNG	ALT	EDITED FRAMES XY	YX	ZZ	FILENAME
300	S	75346	83	63	63	0	0	2392653	329	33.	95.	143.1	6233900	-16.	102.	514.	7569656	82.	93.	547.	0	0	2	J5346010
301	S	75343	83	63	63	2	0	14105136	329	33.	65.	143.1	13441933	-16.	72.	519.	14797659	92.	65.	542.	2	2	1	J5346030
302	S	75346	83	63	63	2	0	21015719	329	33.	39.	142.9	20657966	-16.	42.	514.	22013723	92.	35.	547.	41	35	43	J5346051
303	S	75346	83	63	63	2	0	28527991	329	33.	9.	143.2	27365745	-17.	11.	519.	29221456	32.	5.	543.	113	122	114	J5346070
304	S	75346	83	63	63	2	0	36705935	328	32.	336.	143.2	35601694	-16.	341.	512.	36437426	82.	335.	549.	235	469	434	J5346090
305	S	75343	83	63	63	2	0	42943740	328	32.	308.	143.3	42259742	-17.	311.	514.	43645438	31.	305.	547.	73	67	96	J5346110
307	S	75346	83	63	63	2	0	57069536	328	32.	248.	143.1	54705555	-17.	251.	516.	58061296	81.	245.	543.	166	164	235	J5346150
309	S	75346	83	63	63	2	0	73735732	327	31.	189.	143.0	71121530	-16.	191.	519.	72477263	30.	185.	542.	25	23	32	J5346190
310	S	75346	83	63	63	2	0	78654549	326	31.	159.	143.0	78529547	-16.	161.	518.	79685301	86.	154.	542.	54	49	57	J5346210
312	D	75349	83	63	63	2	0	25941	600	31.	96.	143.0	25671	47.	127.	159.	561440	96.	123.	635.	0	0	0	J5349000
313	D	75349	83	63	63	2	0	14214436	325	30.	67.	142.9	12441234	-26.	71.	638.	14389438	35.	65.	633.	114	109	109	J5349030
314	D	75349	83	63	63	2	0	21420426	326	30.	37.	142.3	20549651	-26.	41.	635.	22193671	35.	33.	631.	130	132	138	J5349050
315	D	75349	83	63	63	2	0	28524625	325	30.	7.	143.1	27648631	-26.	11.	641.	29405270	95.	3.	635.	53	41	41	J5349070
316	D	75349	83	63	63	2	0	35630675	325	30.	337.	143.1	35057530	-26.	340.	638.	36365319	34.	333.	633.	133	151	333	J5349090
317	D	75349	83	63	63	2	0	42332835	324	30.	307.	143.1	42257890	-27.	310.	642.	43313130	34.	303.	637.	36	23	43	J5349110
318	D	75349	83	63	63	2	0	50257339	324	30.	277.	143.1	49455344	-27.	280.	638.	51013055	34.	273.	632.	33	41	40	J5349130
319	D	75349	83	63	63	2	0	57440274	324	29.	247.	143.0	56665295	-27.	250.	641.	53221055	34.	243.	636.	26	20	20	J5349151
320	D	75349	83	63	63	2	0	64543749	323	29.	217.	142.9	63373253	-27.	220.	635.	65417244	84.	213.	631.	25	26	28	J5349170
321	D	75349	83	63	63	2	0	71546706	323	29.	187.	142.9	71073459	-27.	190.	637.	72621202	83.	18 .	623.	25	42	33	J5349190
322	D	75349	83	63	63	2	0	78146174	323	29.	157.	142.9	78273427	-26.	160.	639.	79829171	84.	153.	640.	225	201	359	J5349210
324	S	75350	83	63	63	2	0	6148782	322	28.	95.	142.9	6363235	-21.	99.	517.	7741025	77.	93.	542.	0	0	0	J5350011
325	S	75350	83	63	63	2	0	14247630	322	23.	65.	142.9	13569135	-21.	69.	517.	14949920	77.	63.	542.	85	95	89	J5350030
326	S	75350	83	63	63	2	0	21447715	321	23.	36.	142.8	20765219	-21.	39.	516.	22140951	77.	33.	542.	136	169	161	J5350050
327	S	75350	83	63	63	2	0	28647691	321	28.	6.	142.3	27965143	-21.	9.	515.	29349839	77.	3.	543.	21	23	32	J5350070
330	S	75350	83	63	63	2	0	35845947	321	28.	336.	142.3	35165201	-21.	339.	513.	36540944	77.	333.	545.	143	228	253	J5350090
331	S	75350	83	63	63	2	0	50240326	320	27.	276.	142.3	49577777	-22.	279.	516.	50932224	76.	273.	542.	20	20	21	J5350130
331	S	75350	83	63	63	2	0	57447808	320	27.	246.	142.3	56777059	-22.	249.	513.	58132806	76.	243.	545.	39	35	42	J5350150
332	S	75350	83	63	63	2	0	64633039	320	27.	216.	142.2	63763041	-22.	219.	517.	65324730	76.	213.	541.	27	25	29	J5350170
333	S	75351	83	63	63	2	0	71528336	319	27.	186.	142.1	71169123	-22.	189.	512.	72524858	76.	182.	545.	15	20	22	J5350190
334	S	75350	83	63	63	2	0	79324507	319	26.	156.	142.2	78061515	-23.	159.	516.	79716747	76.	153.	542.	41	29	25	J5350210
335	D	75351	83	63	63	2	0	7012995	312	25.	96.	142.2	6240995	-30.	99.	635.	7768746	81.	92.	632.	0	0	0	J5351011
337	D	75351	83	63	63	2	0	14207249	317	25.	65.	142.1	13462598	-30.	69.	636.	14963748	81.	62.	640.	57	59	59	J5351030
338	D	75351	83	63	63	2	0	21399500	317	25.	35.	142.1	20625000	-31.	39.	637.	22160756	81.	32.	639.	36	35	38	J5351050
339	D	75351	83	63	63	2	0	28591758	317	25.	5.	142.1	27517007	-31.	9.	637.	29372750	80.	2.	635.	28	29	26	J5351070
340	D	75351	83	63	63	2	0	35783763	317	25.	335.	142.1	35069713	-31.	339.	637.	36564752	87.	332.	639.	63	96	182	J5351090
342	D	75351	83	63	63	2	0	50165528	317	25.	275.	142.1	49392779	-31.	279.	634.	50940526	79.	272.	632.	56	60	37	J5351131
344	D	75351	83	63	63	2	0	64543231	315	24.	215.	142.0	63768782	-32.	219.	638.	65324511	79.	212.	637.	22	22	24	J5351171
345	D	75351	83	63	63	2	0	71732391	315	24.	185.	141.9	70952068	-32.	189.	644.	72543644	79.	182.	632.	64	59	63	J5351190
346	D	75351	83	63	63	2	0	78920733	315	24.	155.	142.0	78144559	-32.	158.	635.	79700725	79.	152.	636.	52	43	54	J5351211
348	S	75352	83	63	63	2	0	6594774	314	24.	95.	142.0	6222779	-25.	98.	515.	7533518	73.	92.	541.	121	147	141	J5352010
349	S	75352	83	63	63	2	0	14031452	314	23.	65.	141.9	13415716	-26.	68.	516.	14772456	72.	62.	538.	23	18	33	J5352030
350	S	75352	83	63	63	2	0	21267136	314	23.	35.	141.7	20563611	-25.	33.	511.	21964351	73.	32.	544.	20	26	18	J5352050
351	S	75352	83	63	63	2	0	28453811	313	23.	5.	141.7	27792556	-26.	8.	512.	29143296	72.	2.	543.	86	107	132	J5352070
352	S	75352	83	63	63	2	0	35639143	312	23.	335.	141.7	34976393	-26.	338.	514.	36332143	72.	332.	542.	16	16	16	J5352090
353	S	75352	83	63	63	2	0	42822395	312	23.	305.	141.6	42160395	-26.	308.	514.	43516145	72.	302.	541.	25	30	25	J5352110
354	S	75352	83	63	63	2	0	51087596	312	22.	275.	141.3	49544591	-26.	278.	514.	50701351	72.	272.	542.	46	52	51	J5352130
355	S	75352	83	63	63	2	1	57191249	312	22.	245.	141.7	56528739	-27.	248.	513.	57884491	72.	242.	543.	22	32	32	J5352151
356	S	75352	83	63	63	2	0	64371950	311	22.	215.	141.6	63712724	-27.	218.	511.	65068465	71.	212.	544.	24	20	22	J5352170
357	S	75352	83	63	63	2	0	71555515	311	22.	185.	141.6	70863754	-27.	188.	517.	72244516	71.	182.	538.	93	93	93	J5352198
358	S	75352	83	63	63	2	0	78736453	311	22.	155.	141.7	78072458	-27.	158.	515.	79423197	71.	152.	540.	32	36	32	J5352210

Figure 17. Report Generated from the HEADHIST Files

2.3 Special Analysis Program

In addition to the MESA DRS and MESA utility programs, there are other MESA programs which were written to further analyze experimental data. We will present here a brief description of some of those used for data analysis.

2.3.1 ATTCOM – In order to evaluate the accuracy of the spacecraft generated attitude data, a routine was written to compare MESA-generated attitude data with the spacecraft generated attitude. MESA attitude is calculated between the altitudes of 180 - 200 km, since C-range MESA data saturates at lower spacecraft altitudes. Algebraic differences are calculated for this region, and a printed report is generated.

This routine may be run against any orbit of data where spacecraft attitude values are suspect.

2.3.2 NORMALS – In analyzing density data, it is helpful to attempt to remove certain effects in order to study effects due to other causes. To this end a computer routine was written which would normalize calculated density data to a specific altitude and/or local time which in effect would remove density effects due to these parameters. Resultant normalized density may then be more easily analysed for other effects (such as magnetic index effects). Normalized density is calculated by:

$$\text{Normalized density} = \frac{\text{measure density x model density (at the normalized altitude and/or local time)}}{\text{model density}}$$

Model density values are calculated using the JACCHIA 71 Model atmosphere.

Printer listings of normalized density data as a function of time and satellite position information are generated from this program.

Figure 18 is an example of this listing showing data normalized to an altitude of 200 km and a local time of 7.5 hours.

2.3.3 UAINTER – The Unified Abstract (UA) file data base was organized in order to store simultaneous measurements from as many experiments as possible. For this reason the UA file was setup as a function of Greenwich Mean Time (GMT) at specific 15 second increments. In order to compare data over many orbits, however, it was determined that comparison by satellite altitude rather than by GMT should be done.

Hence, a computer program was written which reads data from both the UA point-by-point files and the spacecraft orbit/attitude (OA) files. MESA density data are then interpolated at specific altitudes for each orbit of data stored in the UA files. Interpolated MESA density values along with associated orbit/attitude position data were punched on data cards and shipped to AFGL.

These data cards were then utilized as input to various other analysis programs written for the AFGL CDC-6600 computer system. Examples of this are given in Figures 19 and 20. In Figure 19 MESA density values at 140 - 200 km are displayed along with magnetic index Kp and satellite perigee latitudes. In Figure 20 MESA density data for 140 km are compared to Jacchia 71 model values.

In addition to generating MESA density data cards, UAINTER was modified to have the capability of extracting from the UA file neutral atmosphere composition data calculated by the OSS experiment. OSS calculated values of nitrogen, total oxygen, and argon are extracted for those orbits where MESA density values are stored. This will provide comparison data of neutral mass density from both experiments, as well as determining a way to provide more accurate knowledge of the lower thermosphere.

FILE NAME IS: NESA.A4194210

AE-C

ORBIT 2437 DATE OF ORBIT 74198
DATE MODEL RUN 76268

KP= 2.3
DAILY FLUX(F7)= 88.0
AVERAGE FLUX(FB7)= 69.1

DECLINATION OF SUN= 21.154

MODEL CALCULATED BY
JACCHIA 71 MODEL

NORMALIZED DENSITY VALUES
ALT = 200.0
LST = 7.5

TIME	LAT	LONG	ALT	LST	DENS	MODEL DENS	MODEL 200	NORMAL 200	MODEL 200/ 7.5	NORMAL 200/ 7.5
[illegible]79	1.5	19.7	235.7	22.45	4.99E-14	5.09E-14	1.67E-13	1.58E-13	1.72E-13	1.62E-13
[illegible]79	2.0	19.8	231.7	22.46	5.52E-14	5.79E-14	1.67E-13	1.62E-13	1.72E-13	1.67E-13
[illegible]	2.5	20.0	227.5	22.47	6.21E-14	6.62E-14	1.67E-13	1.57E-13	1.72E-13	1.62E-13
[illegible]	3.0	20.2	225.5	22.49	7.05E-14	7.52E-14	1.67E-13	1.57E-13	1.73E-13	1.62E-13
[illegible]	3.5	20.4	219.5	22.50	8.00E-14	8.54E-14	1.67E-13	1.57E-13	1.73E-13	1.62E-13
[illegible]	4.0	20.5	215.5	22.51	9.73E-14	9.72E-14	1.67E-13	1.57E-13	1.73E-13	1.72E-13
[illegible]	4.9	20.7	211.9	22.53	1.15E-13	1.10E-13	1.67E-13	1.74E-13	1.73E-13	1.80E-13
[illegible]	5.4	20.9	208.1	22.54	1.37E-13	1.26E-13	1.67E-13	1.83E-13	1.73E-13	1.89E-13
[illegible]	5.9	21.1	204.5	22.55	1.53E-13	1.47E-13	1.66E-13	1.85E-13	1.73E-13	1.92E-13
[illegible]	6.4	21.2	201.0	22.57	1.80E-13	1.62E-13	1.66E-13	1.90E-13	1.73E-13	1.96E-13
[illegible]	6.9	21.4	197.5	22.58	2.11E-13	1.82E-13	1.66E-13	1.95E-13	1.73E-13	2.01E-13
[illegible]	7.5	21.6	194.5	22.60	2.47E-13	2.06E-13	1.66E-13	2.01E-13	1.73E-13	2.05E-13
[illegible]	8.0	21.8	191.0	22.61	2.86E-13	2.35E-13	1.66E-13	2.06E-13	1.74E-13	2.13E-13
[illegible]	8.5	22.0	187.7	22.63	3.33E-13	2.66E-13	1.66E-13	2.11E-13	1.74E-13	2.18E-13
[illegible]	9.0	22.1	184.5	22.64	3.84E-13	3.01E-13	1.66E-13	2.14E-13	1.74E-13	2.21E-13
[illegible]	9.5	22.3	181.7	22.65	4.36E-13	3.40E-13	1.66E-13	2.17E-13	1.74E-13	2.24E-13
[illegible]	10.1	22.5	179.0	22.67	5.02E-13	3.85E-13	1.66E-13	2.19E-13	1.74E-13	2.27E-13
[illegible]	10.6	22.7	175.5	22.68	5.72E-13	4.33E-13	1.66E-13	2.22E-13	1.74E-13	2.30E-13
[illegible]	11.1	22.9	173.5	22.70	6.46E-13	4.87E-13	1.66E-13	2.22E-13	1.74E-13	2.30E-13
[illegible]	11.5	23.1	171.1	22.72	7.25E-13	5.49E-13	1.66E-13	2.22E-13	1.74E-13	2.30E-13
[illegible]	12.2	23.3	168.5	22.72	8.09E-13	6.16E-13	1.66E-13	2.21E-13	1.75E-13	2.29E-13
[illegible]	12.7	23.4	166.2	22.74	9.07E-13	6.92E-13	1.66E-13	2.21E-13	1.75E-13	2.35E-13
[illegible]	13.2	23.6	164.0	22.75	1.01E-12	7.73E-13	1.65E-13	2.20E-13	1.75E-13	2.28E-13
[illegible]	13.7	23.8	161.7	22.77	1.11E-12	8.64E-13	1.65E-13	2.17E-13	1.75E-13	2.25E-13
[illegible]	14.3	24.0	159.7	22.79	1.22E-12	9.60E-13	1.65E-13	2.12E-13	1.75E-13	2.20E-13
[illegible]	14.8	24.2	157.7	22.80	1.30E-12	1.07E-12	1.65E-13	2.05E-13	1.75E-13	2.12E-13
[illegible]	15.3	24.4	155.5	22.82	1.39E-12	1.19E-12	1.65E-13	1.97E-13	1.75E-13	2.05E-13
[illegible]	15.5	24.6	154.0	22.83	1.50E-12	1.31E-12	1.65E-13	1.93E-13	1.76E-13	2.01E-13
[illegible]	15.4	24.8	152.3	22.85	1.64E-12	1.44E-12	1.65E-13	1.91E-13	1.76E-13	1.99E-13
[illegible]	16.9	25.0	150.3	22.86	1.78E-12	1.59E-12	1.65E-13	1.89E-13	1.76E-13	1.97E-13
[illegible]	17.4	25.2	149.2	22.88	1.93E-12	1.74E-12	1.65E-13	1.87E-13	1.76E-13	1.95E-13
[illegible]	17.9	25.4	147.3	22.89	2.07E-12	1.90E-12	1.65E-13	1.85E-13	1.76E-13	1.92E-13
[illegible]	18.5	25.6	145.5	22.91	2.25E-12	2.07E-12	1.65E-13	1.84E-13	1.76E-13	1.92E-13
[illegible]	19.0	25.8	145.3	22.92	2.42E-12	2.24E-12	1.65E-13	1.83E-13	1.76E-13	1.91E-13
[illegible]	19.5	26.0	144.2	22.94	2.60E-12	2.47E-12	1.65E-13	1.82E-13	1.77E-13	1.90E-13
[illegible]	20.0	26.2	143.1	22.96	2.74E-12	2.59E-12	1.65E-13	1.79E-13	1.77E-13	1.87E-13
[illegible]	20.5	26.4	142.2	22.97	2.86E-12	2.75E-12	1.70E-13	1.76E-13	1.77E-13	1.84E-13
[illegible]	21.1	26.6	141.4	22.99	3.01E-12	2.92E-12	1.70E-13	1.75E-13	1.77E-13	1.82E-13
[illegible]	21.6	26.8	140.7	23.00	3.18E-12	3.07E-12	1.70E-13	1.76E-13	1.77E-13	1.80E-13
[illegible]	22.1	27.1	140.0	23.02	3.37E-12	3.21E-12	1.70E-13	1.78E-13	1.77E-13	1.80E-13

Figure 18. Printer Listing Generated by NORMALS

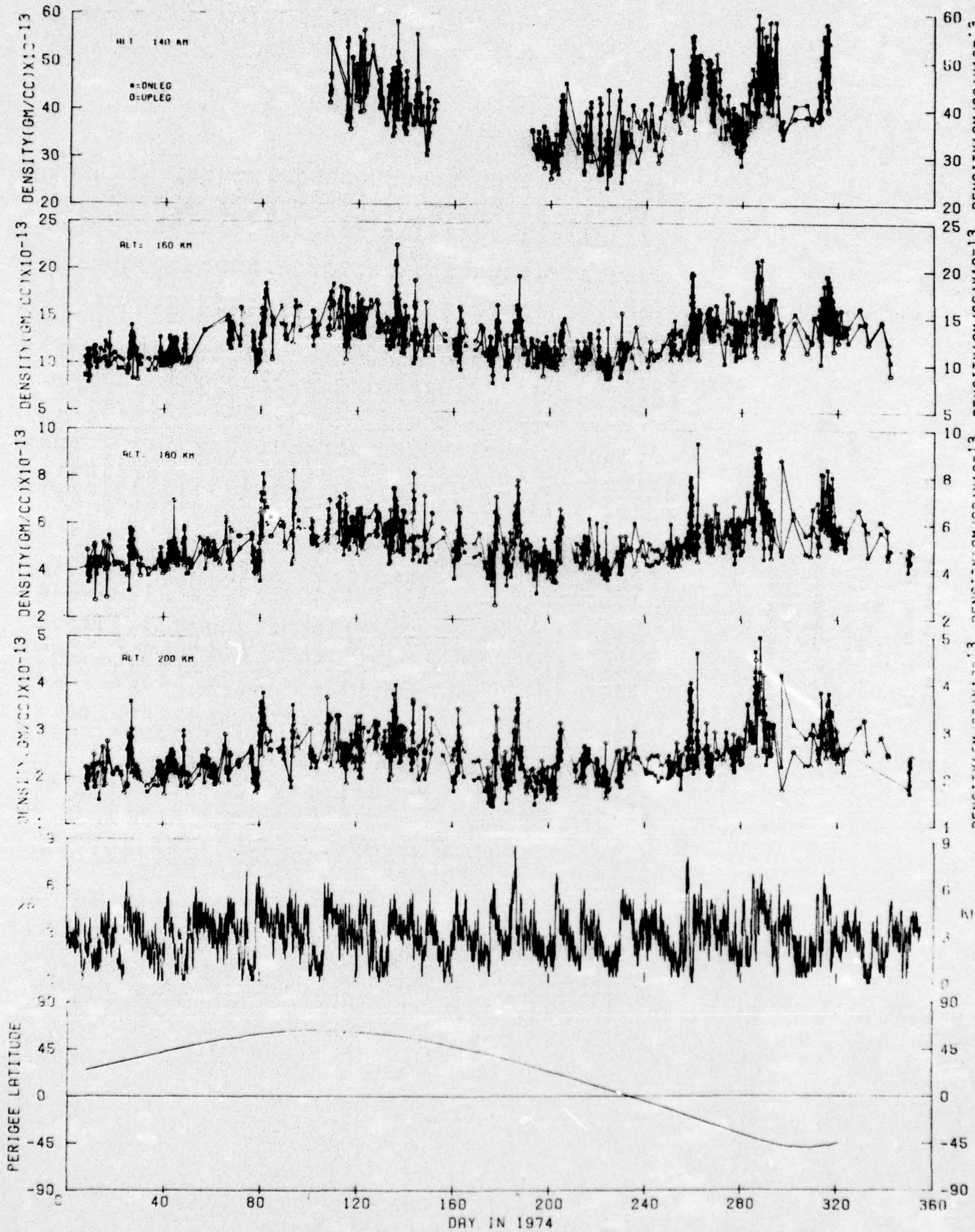


Figure 19. AE-C 140 km MESA Density Data, Magnetic Index Kp, and Perigee Latitude

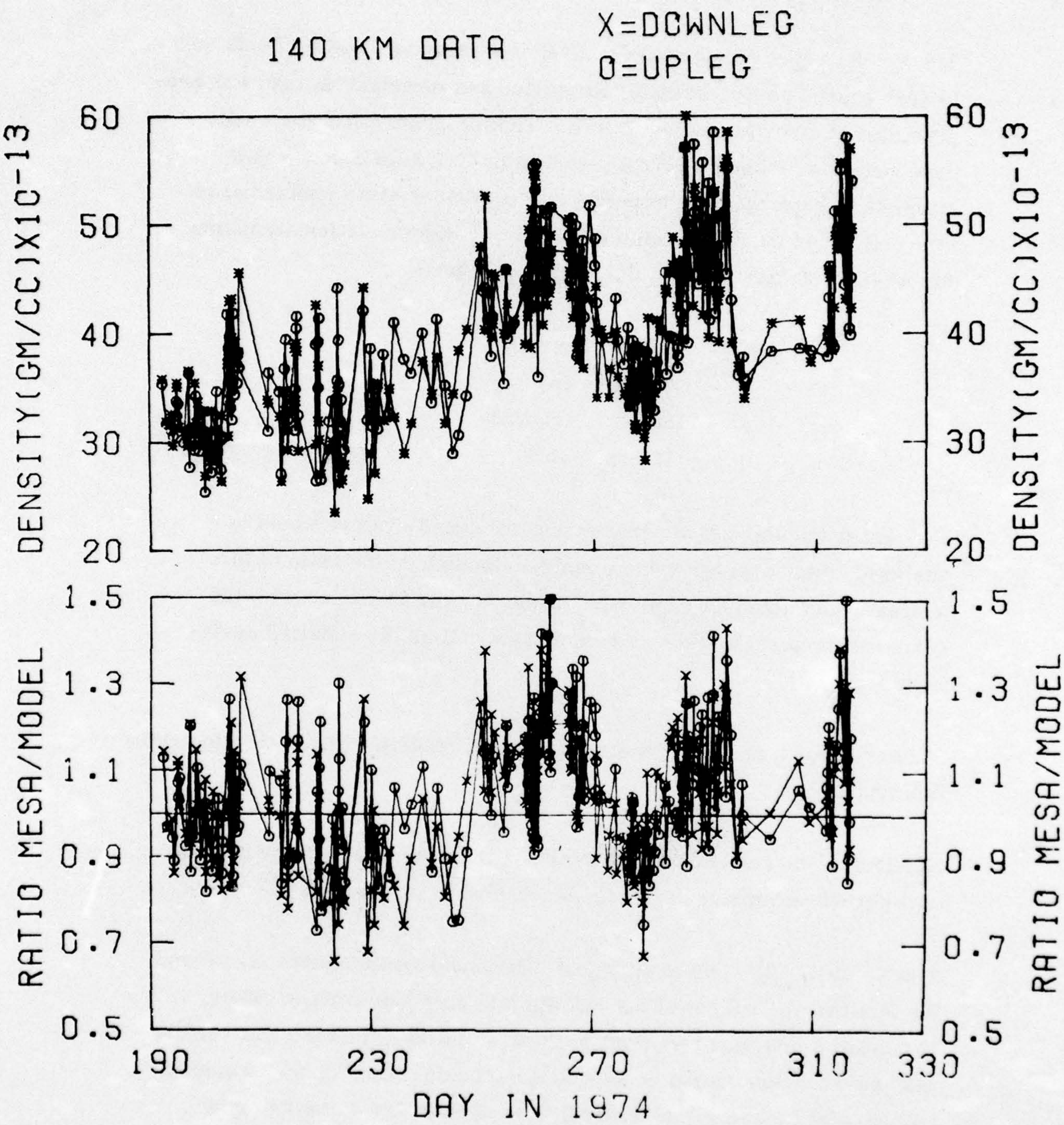


Figure 20. AE-C 140 km MESA Density Data and Jacchia 71 Model Data

2.3.4 STATS – An alternate method of separating density effects due to such causes as Kp, latitude, longitude, and invariant latitude was programmed in a routine called STATS. This program utilized the data base generated from UAINTER (See Section 2.3.3) as input, and it attempts to separate density points into particular atmospheric parameter cells. An example of this would be to consider all density points for AE-C, 160 km, between the following values:

60°	-	70°	latitude
4	-	9	Kp
-180°	-	+180°	longitude
0	-	12 hrs	GMT

For that particular set of parameters, all density values would be analyzed, their average value would be calculated, the ratio of this average value to an average value of the Jacchia 71 model (with the same parameters) would be calculated as well as the standard deviation.

Printer reports are then generated showing results. Figure 21 illustrates this type of output.

STATS is a very useful tool in analyzing these data, since any number of different parameter cells may be chosen.

2.3.5 NUTAT – Due to stringent instrument requirements on AE and the fact that the AE satellites will dip into very low-perigee orbits, it is essential that the spacecraft be quite stabilized, that is, that vehicle motions such as nutation be kept to a minimum. On AE, nutation angle buildup may be controlled either by use of on-board dampers or by judicious use of momentum wheel speed. In order to effect these controls it is necessary to monitor their results. This may be accomplished by use of the MESA experiment.

OBSERVED/MODEL DENSITY STATISTICS
AE-C MESA VS. JACCHIA 1971
ALTITUDE -- 140.0 KM

CASE NO.	LATITUDE DEGREES MIN	LATITUDE DEGREES MAX	KP MIN	KP MAX	LONGITUDE DEGREES MIN	LONGITUDE DEGREES MAX	GMT HHMMSS MIN	GMT HHMMSS MAX	INVARIANT LATITUDE MIN	INVARIANT LATITUDE MAX	NO. OF POINTS	AVERAGE OBSERVED	AVERAGE OBSERVED /MODEL	STANDARD DEVIATION
1	-90.0	-80.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0.
2	-80.0	-70.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0.
3	-70.0	-60.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	33	4.08E-12	1.103	6.4[illegible]E-02
4	-60.0	-50.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	15	4.64E-12	1.09[illegible]	1.[illegible]E-01
5	-50.0	-40.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	69	4.55E-12	1.062	1.51E-01
6	-40.0	-30.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	50	4.36E-12	1.[illegible]	2.6[illegible]E-01
7	-30.0	-20.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	58	4.44E-12	1.129	2.24E-01
8	-20.0	-10.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	34	4.51E-12	1.134	3.91E-02
9	-10.0	0.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	19	3.59E-12	.94[illegible]	2.7[illegible]E-01
10	0.0	10.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	30	3.31E-12	.91[illegible]	4.57E-02
11	10.0	20.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	40	3.50E-12	.962	1.45E-01
12	20.0	30.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	41	3.31E-12	.979	1.1[illegible]E-01
13	30.0	40.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	4	3.22E-12	.973	1.[illegible]E-01
14	40.0	50.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0
15	50.0	60.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	38	3.95E-12	1.055	6.9[illegible]E-02
16	60.0	70.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	97	4.50E-12	1.144	1.4[illegible]E-01
17	70.0	80.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0.
18	80.0	90.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0

OBSERVED/MODEL DENSITY STATISTICS
AE-C MESA VS. JACCHIA 1971
ALTITUDE -- 160.0 KM

CASE NO.	LATITUDE DEGREES MIN	LATITUDE DEGREES MAX	KP MIN	KP MAX	LONGITUDE DEGREES MIN	LONGITUDE DEGREES MAX	GMT HHMMSS MIN	GMT HHMMSS MAX	INVARIANT LATITUDE MIN	INVARIANT LATITUDE MAX	NO. OF POINTS	AVERAGE OBSERVED	AVERAGE OBSERVED /MODEL	STANDARD DEVIATION
1	-90.0	-80.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0.
2	-80.0	-70.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0.
3	-70.0	-60.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	59	1.53E-12	1.123	3.3[illegible]E-01
4	-60.0	-50.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	61	1.53E-12	1.127	1.32E-01
5	-50.0	-40.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	27	1.27E-12	1.07[illegible]	2.93E-02
6	-40.0	-30.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	49	1.46E-12	1.134	2.2[illegible]E-01
7	-30.0	-20.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	39	1.42E-12	1.142	2.9[illegible]E-02
8	-20.0	-10.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	35	1.37E-12	1.154	1.2[illegible]E-01
9	-10.0	0.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	36	1.23E-12	1.019	9.7[illegible]E-02
10	0.0	10.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	27	1.22E-12	1.073	1.23E-01
11	10.0	20.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	32	1.13E-12	1.039	[illegible]E-02
12	20.0	30.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	58	1.14E-12	1.050	2.2[illegible]E-01
13	30.0	40.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	118	1.15E-12	1.041	4.93E-02
14	40.0	50.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	123	1.18E-12	1.039	5.41E-01
15	50.0	60.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	62	1.39E-12	1.137	4.4[illegible]E-02
16	60.0	70.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	157	1.40E-12	1.172	6.27E-03
17	70.0	80.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0.
18	80.0	90.0	2.000	7.000	-180	180	0	240000	-90.0	90.0	0	0.	0.000	0.

Figure 21. Observed/Model Density Statistics

We developed a printer plotting routine to display nutation amplitude and frequency as a function of GMT, by displaying the MESA XY-sensor output data taken above 300 km. From this preliminary nutation information may be determined from inspection and some minor calculations.

However, since more automated techniques were desired, we developed a routine called NUTAT, which using raw MESA sensor data as input, calculated nutation angle and frequency directly. This routine utilized mathematical modelling and optimization techniques. Results agreed favorably with those calculated by the initial printer plot routine.

2.4 Data Processing Summary

As a result of this contract, we have processed over 2000 orbits of AE-C MESA telemetry data into geophysical parameters and stored these results in files (called GU files) on the Sigma-9 computer. In addition, in support of the AE Aeronomy Team, data from more than 1000 of these orbits have been written into Unified Abstract (UA) files which are accessible for use by all other experimenters and theoretical analysts.

In the short time since the launches of AE-D and AE-E, 260 orbits of AE-D MESA data and 80 orbits of AE-E data have been processed and stored in GU files. Of these, 200 orbits of AE-D data and 65 orbits of AE-E data have been written into UA files for use by other team members.

We feel that the data bases generated from this project will be extremely useful in any further studies of the phenomena of the upper atmosphere.

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4. REFERENCES

[1] A. Dalgarno, W. Hanson, N. Spencer, and E. Schmerling, The Atmosphere Explorer Mission, Radio Science, Volume 8, Number 4, pp. 263, April 1973.

[2] J.R. Thompson, Atmosphere Explorer Data Processing System Central Computer Data Management Facility User's Guide, TM-3005, Contract NAS 5-11999, Computer Science Corporation, June 1974.

[3] K.S.W. Champion and F.A. Marcos, The Triaxial Accelerometer System on Atmosphere Explorer, Radio Science, Volume 8, Number 4, pp. 297-303, April 1973.

[4] J.P. Noonan, R.W. Fioretti, and B. Hass, Digital Filtering Analysis Applied to the Atmosphere Explorer-C Satellite MESA Accelerometer Data, AFCRL-TR-75-0293, Contract F19628-73-C-0142, RDP, Incorporated, Waltham, Mass., February 1975.